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DO YOU KNOW

► . . . . That with the start of a New Year the JOURNAL may be out on schedule? The January issue is perhaps being mailed in January! It has been a difficult year of trying to invent ways of catching up the initial deficiency of circumstances, but we will do our best to stay on schedule for the remainder of the year. Some rather drastic steps needed to be taken, and this goal hasn't been reached without struggles and sacrifices. We will no doubt still get some complaints because of the new timing, but at least they will be different complaints.

One change affecting deans is the probable omission of "Engineering Enrollments and Degrees, 1956" from next month's Yearbook. In the old days when the deans were asked for the statistics, some reports came in late because the data had to be obtained from the college recorders. So, last year and this, the statistics were requested directly from the recorders. As of the middle of November, some colleges still had not submitted the necessary information, and without completeness what is the value of the tabulation? The Office of Education has cooperated admirably, but what can they do if the statistics are not submitted promptly? In past years the publication of the Yearbook was delayed to include the statistics; this year we decided to produce on schedule, regardless. You see, if February is late, March, April, May and June must be late also; the printer has the capacity to produce only one issue per month, and cannot catch up or accelerate the process. The quick reply might be to get a different printer, but until we know we can supply material regularly and systematically there is no merit in making a change; we might well merely have the same cold stew in a different pot.

► . . . . That to get the September JOURNAL to you in September and the other fall issues out on time we need to have copies of as many Annual Meeting papers *in advance* of the Annual Meeting as possibly can be collected? We intend again to make the September an Annual Meeting issue, but almost all the material will have to be in the Editor's hands by June first. Program chairmen, Division chairmen, Committee chairmen, and speakers, please heed this plea for cooperation.

► . . . . That early plans of the technical subject matter Divisions for the Annual Meeting at Cornell indicate a desire to improve communication with non-technical subject matter Divisions? Programs where the subject relates to such topics as English, physics or mathematics—either directly or indirectly—should include those Divisions. They also should have an opportunity to participate in planning the programs. The resolution of difficulties is a two-sided problem and all involved should have a chance to contribute.

► . . . . That plans for the ECRC Survey of Research Facilities are crystallizing? Both personal visits and a questionnaire will be used. A four-man team is being organized at each of the following schools; New York University, Penn State, Purdue, and

Oklahoma A. & M. During next summer one or two members of these teams will visit institutions having curricula accredited by ECPD to gather the information in the areas of the approved curricula.

► . . . . That during the past year four institutional members have been added to the list of those participating in ECRC? They are Worcester Polytechnic Institute, Johns Hopkins University, University of Wichita, and the Air Force Institute of Technology.

► . . . . That the Secretary of ECRC, Professor Renato Contini of New York University, is busy with the preparation of the 1957 "Review of Current Research and Directory of Member Institutions"? Questionnaires were mailed some time ago and editing of the returns is under way. General plans are to "unveil the volume" at the Annual Meeting. Sales of the 1955 edition were higher than previously, and probably reflect the more widespread interest of colleges of engineering in research programs and greater industry concern about what the colleges are doing.

► . . . . That the Engineering Division of the Association of Land-Grant Colleges and State Universities voted to discontinue the publication of its "Engineering Record"? The volume now in press is to be the last one. The major reasons for discontinuance are that our ECRC Review of Current Research and Directory of Member Institutions is more comprehensive and complete, and that there is no need for two publications doing essentially the same thing.

► . . . . That a few thoughts expressed at the recent meeting of Association of Land-Grant Colleges and State Universities by Irvin Stewart in his presidential address seem worthy of repetition? "The most difficult problems in the world today are not in science but in human relations . . . . and it will challenge our best students to come up with the right answers in time. . . . . Even though none of our faculty members may have the solutions, that does not mean that their students will be equally limited. . . . . The best students build upon the instructor and go beyond anything of which the instructor is capable. . . . . I suggest that our task is to stimulate intellectual curiosity and intellectual integrity in our students. Of the two, the latter is by far the more urgently needed. . . . . They (our students) may be deeply influenced by evidence from us that integrity is considered more than a topic for a Sunday sermon."

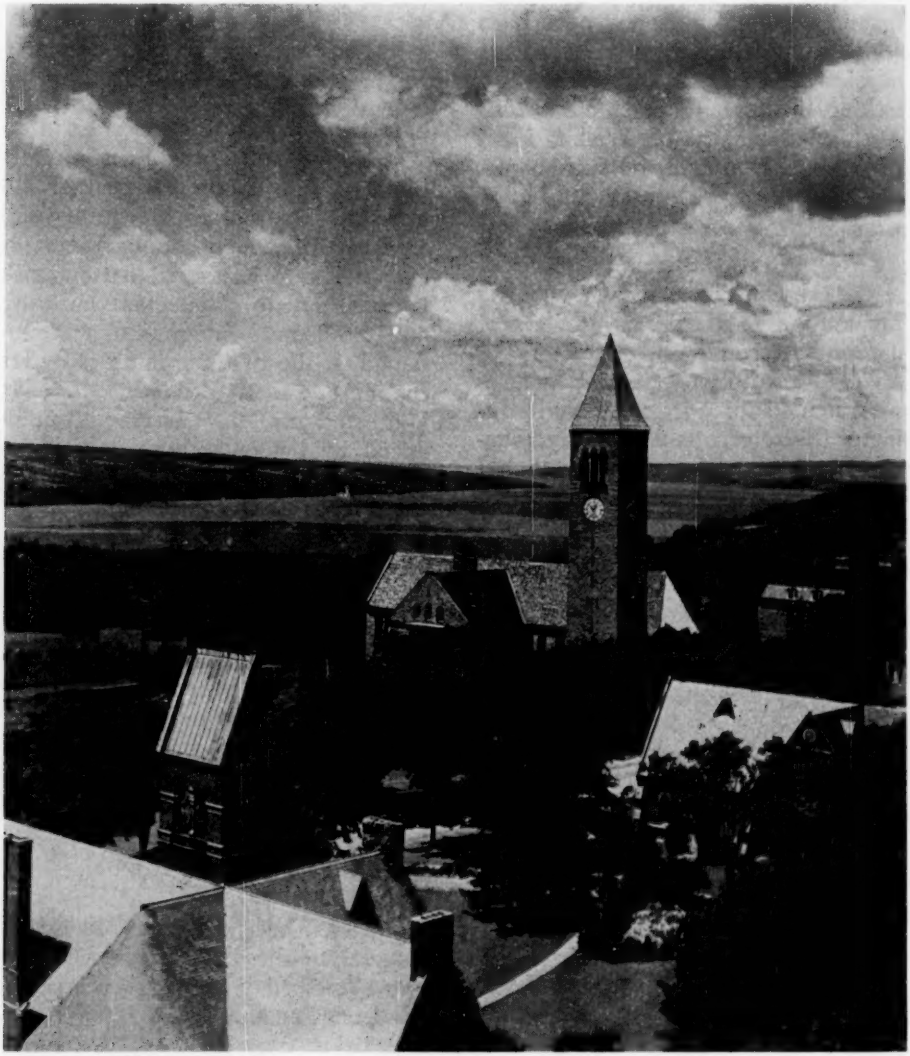
► . . . . That at the October meeting of the General Council, twelve of the sixteen representatives and seventeen of the twenty-two Division representatives were present? Last year the numbers were eleven and seven, respectively, and two years ago eight and ten. It seems as though paying travel expenses improves attendance; that, of course, is what was desired.

► . . . . That the entire office staff sincerely wishes each of you a Happy New Year? May the year ahead be a good one for all!

W. Leighton Collins
Secretary

CORNELL UNIVERSITY WELCOMES ASEE FOR 1957 MEETING

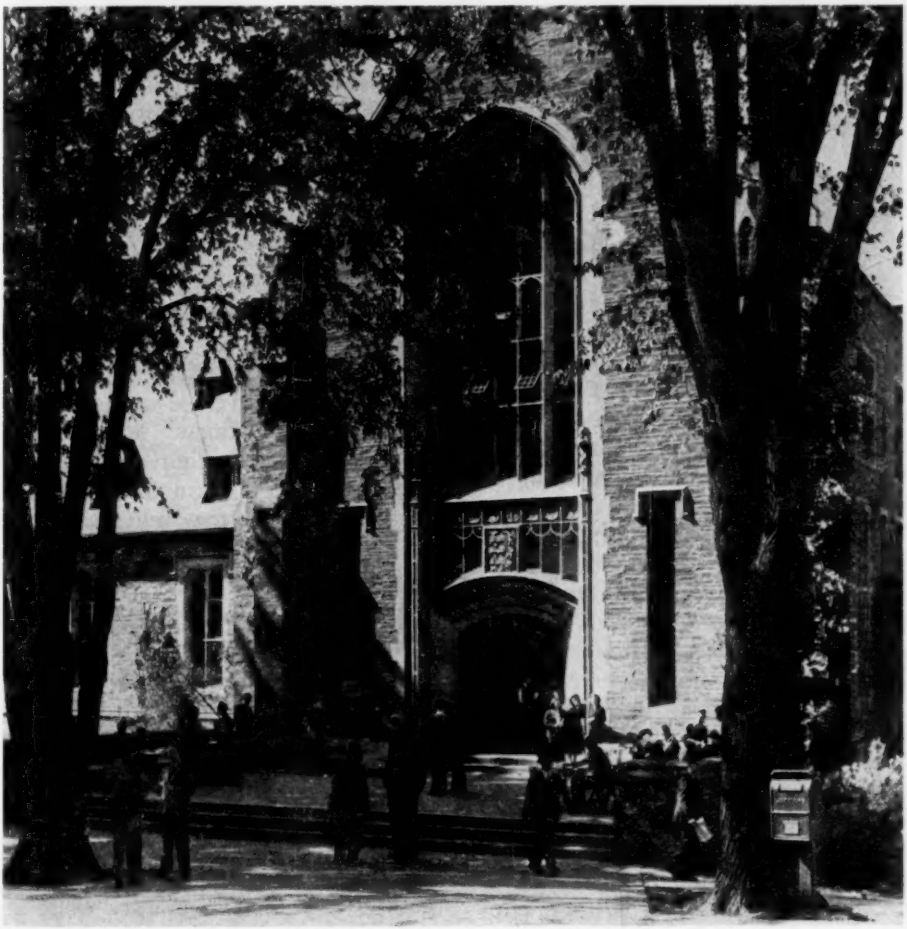
Cornell University, "far above Cayuga's waters" in the scenic Finger Lakes region of New York State, will be host to the sixty-fifth annual meeting of ASEE, June 17-21, 1957. The meetings offer a splendid chance to combine Society and professional interests with a vacation for the family.



Far above Cayuga's waters stands the chimes tower of the Cornell University Library, the landmark of the campus.

Cornell has been described as the most western of the eastern universities, and the most eastern of the western. It is an Ivy League school and a land-grant college. It has privately-endowed and state-supported divisions. Its more than 10,000 students come from every state in the union and from 70 foreign countries. The faculty has more than 1,300 active members of professorial rank, and the University libraries house more than 1,800,000 volumes.

The campus alone, with its two bordering gorges, waterfalls, Beebe Lake, and view of Cayuga Lake, has beauty enough to merit a visit. Other points of interest are the University Library with its 173-foot bell tower; Anabel Taylor Hall, an interfaith center; Statler Hall, housing the hotel administration school and practice inn;



Willard Straight Hall, the student union at Cornell, will be headquarters for the 65th Annual Meeting of ASEE.

the Willard Straight Hall, the student union; the Andrew Dickson White Museum of Art; the Lua A. Minns Memorial Garden; and a 16-unit Veterinary College, completed this year.

New Engineering Quadrangle

Rapidly taking shape is a completely new engineering quadrangle. Buildings are already finished for chemical engineering, electrical engineering, and mechanics and materials. Under construction are an administration and library building, and a mechanical engineering building with an aeronautical engineering wing. Construction of a new civil engineering building will begin in 1957. Other facilities include a new agricultural engineering building, a high-voltage laboratory, and a radio astronomy observing station.

With an enrollment of nearly 2,000 undergraduates, the College of Engineering has divisions of chemical and metallurgical, civil, electrical, mechanical, aeronautical engineering (a graduate school), and engineering physics. Agricultural engineering is under the College of Agriculture. The College of Engineering in 1946 introduced five-year undergraduate programs, which are now standard in all its divisions.

History

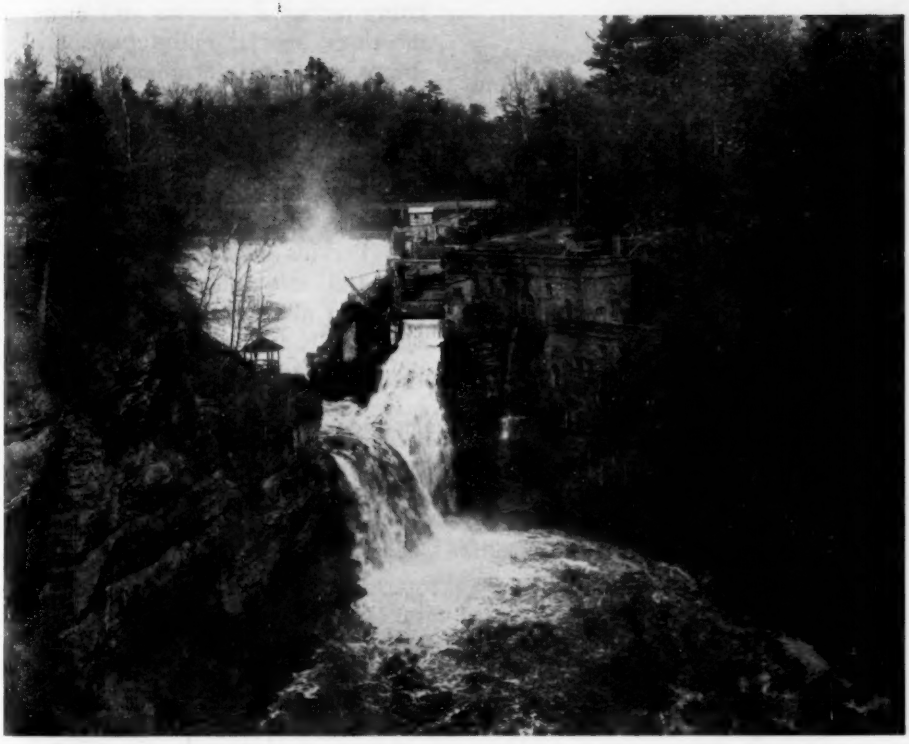
The founders of Cornell University, Ezra Cornell and Andrew Dickson White, first met in 1864 as members of the New York State Senate. Mr. Cornell was a self-educated man, an inventor whose fortune came from the then new telegraph. Mr. White was an urbane professor of history, educated at Yale and abroad. As these two men put their energy, time, and money into a new university, their thoughts and dreams together formed its philosophy.

From Mr. Cornell came the university's motto, "I would found an institution where any person can find instruction in any study." From him came the school's beautiful campus, and a large part of its endowment. As a co-founder and first president, Mr. White contributed a pioneering concept of education, in reaction against the diet of dehydrated classics and mathematics he had encountered in his own college days.

Soon after they met, however, the two as state senators found themselves on opposite sides of a debate about the Morrill Act granting federal lands to states, which would use the returns for agricultural and mechanic training. Mr. Cornell thought New York's share should be divided among several schools; Mr. White thought it should all go to one. That Mr. White won Mr. Cornell over, showed the former's persuasiveness—and the latter's open-mindedness. Mr. Cornell went further, adding gifts of $500,000 and his 200-acre farm in Ithaca for the benefit of the new university.

Academic Pioneer

As first president, Mr. White faced ridicule and criticism for offering courses in agriculture, engineering, and veterinary medicine on an equal academic footing with traditional subjects. Cornell was the first non-technical institution of higher learning to offer engineering courses. At the same time, it pioneered with the nation's first courses in American history. It greatly expanded laboratory work in the sciences, and had the first experimental psychology facilities in this country.



Cornell Engineers utilized as a hydraulic laboratory one of the gorges that border the campus. Beebe Lake, above the falls, is convenient for swimming.

Its academic pioneering has continued in this century, when it founded the first schools of electrical engineering, hotel administration, nutrition, and industrial and labor relations. It introduced five-year programs in architecture as well as engineering, the "spoken approach" in language instruction, and a combined approach in teaching business and public administration.

Research has been emphasized since the early days of the College. An important initial project was the design and construction of the hemisphere's first practical dynamo, which in 1870 powered the nation's first outdoor electric lighting. From this beginning grew the University's present research program, with outside funds alone of $25,000,000, which covers the physical and intellectual universe. Facilities entirely for research include agricultural experiment stations, the Cornell Aeronautical Laboratory in Buffalo, N. Y., the Floyd Newman Laboratory of Nuclear Studies in Ithaca, housing a 1.5 billion-electron-volt synchrotron, and anthropological stations in Peru, India, Thailand, Nova Scotia, and the American Southwest.

Travel

Ithaca is served by Mohawk Airlines, Lehigh Valley Railroad (from New York, Philadelphia, or Buffalo) and Greyhound Bus. Visitors driving from the west or east will have an opportunity to travel the New York State Thruway, which passes 50 miles from Ithaca.

Cornell committees for the ASEE meetings plan to house all visitors on the campus. To supplement the stimulating technical sessions and business meetings, special entertainment programs are being arranged for men, women, and children. There will be picnics at nearby parks and gorges, opportunities for swimming, golf, tennis, and other sports, plus trips to the Corning Glass Works, the Jackson and Perkins Company rose gardens, and the salt mines under Cayuga Lake. In all, Cornell expects to provide ASEE a very pleasant visit.

Cornell University Committee for the Annual Meeting

General Chairman.....J. C. Gebhard
Vice Chairman.....J. F. McManus

Committee Chairmen

Banquets and Luncheons.....B. J. Conta
Conferences and Sessions.....A. H. Burr
Entertainment and Excursions.....J. O. Jeffrey
Finance.....G. R. Hanselman
General Service.....H. H. Mabie
Hospitality.....D. H. Moyer
Housing and Food.....N. R. Gay
Publicity and Information.....A. J. McNair
Registration.....E. M. Strong
Summer Schools and Exhibits.....N. A. Christensen
Transportation.....O. C. French
Women's and Young People's Program.....Mrs. H. H. Mabie and Mrs. C. L. Cottrell

Annual Meeting, June 17-21, 1957

SO YOU'RE GOING TO "READ" A PAPER!

HAROLD O. HASKITT, JR.

Head, Speech Section,
General Motors Institute, Flint, Michigan

Prepared at the request and with the support of the English Division, as part of the "improve-the-Sessions" movement. (See "Candid Comment" by William H. Crew, September, page 23.)

With your permission I'm going to assume that you have been asked to "present" or "read" a "paper" at a convention session of your primary technical society. Your topic has been selected and the session chairman has indicated a definite time limit. —Now what do you do? If you are like most of us, you will probably get your notes together, *write* your "paper," have it mimeographed, run through it aloud a time or two, and then present it at the meeting by reading it in a non-too-effective way to your disappointed peers.

When you have finished, you breathe a sigh of relief and comfort yourself with the thought that you have made copies of the "paper" available in printed form—just in case someone didn't understand or remember what you had to say. If this has not happened to you personally, you perhaps can recall similar instances in convention situations where you have been the "listener' to such a talk. After such sessions you may have had the feeling, either as speaker or listener, that somehow it might have been better.

Somehow you were not satisfied that a good job of communicating had been done. But before you could get around to doing much thinking about how it might have been improved, you became involved in other activities and responsibilities which crowded it out of your mind until the next convention or the next speech. Toward the purpose of seeing what the speaker might do before his next talk, let's take a look at some of the elements in the complex process of getting ideas across to individuals in an audience.

Communication, not presentation, of ideas involves more than the transmission of thoughts by you as a speaker to or at a listener. At almost the same instant that the listener is receiving the thought-content of the talk, he is also receiving clues which he uses to build an evaluation of you as a person: professional expert, colleague, and fellow *human* being.

These things directly affect his feelings and attitudes as a listener, and may well determine how much of the thought (content) he understands and carries away with him. When an audience member goes away from a convention meeting saying, "I came to hear the *man,* not just his paper. I could have stayed at home and got more out of it by reading the speech myself," isn't he saying to a speaker,

"I want to know both *you and* your ideas—please talk *with* me on a person-to-person basis, not *at* me as if I were a cabbage-head."?

The fact that in listening, a person *feels* at the same time that he *thinks,* accounts for the fast-growing use over the past few years of the extemporaneous method of speech delivery. Each listener wants to feel that the speaker is carrying on a friendly, highly spirited, organized conversation with him (and the others in the group) on a subject which is highly informative and interesting to both parties in the discussion. Now, what can a convention speaker do to improve his chances of communicating effectively? The following may suggest ideas to you which you may find at least worth thinking about if not worth actually using at some time.

Know Your Subject

It is almost too obvious that a good communicator must be saturated with his subject. The concepts you are going to discuss should be so thoroughly thought through that you will have no difficulty in capturing and recapturing the bases for each main point and its supporting details at the time you are bringing them out. Each idea expressed should stem from a clear-cut basis in thought, and, whenever possible, your visualization of ideas expressed should be vivid and intense.

Even the words you use should be carefully selected in terms of the pictures, concepts, and interest that they arouse, both in the speaker *and* the listener. For, generally speaking, the more a speaker knows and the sharper his perceptions are about a subject, the more interested he becomes in it, until he actually finds himself anxious to share it with others.

Organize for Your Listener

Body of the Talk. The main reason for organizing material is to help the listener understand it more completely, more rapidly, and more easily, even with a minimum of effort. This means then that the subject matter should be put together in a structural pattern which the listener can recall easily later on, and which he can recreate quickly for himself as the speaker is talking.

Main points should be limited in number (no more than five), and worded in a concise, clear, and interesting way. Explanations, illustrations, facts, and other supporting materials for these principal ideas should be selected to capture the greatest listener interest and understanding in the limited time allowed the speaker. If certain content materials will cause audience interest to lag, they should be simplified, eliminated, or presented in a different way.

Introduction of the Talk. The function of the introductory portion of a speech is to get the audience warmed up and in a receptive frame of mind to understand and accept the main ideas to be brought out. During this period a listener is very busy trying to focus his attention and to evaluate the elements that go to make up your particular personality. At the same time, he is trying to establish in his mind the specific central idea and your approach to it so that he can build his own "speech" as the talk unfolds.

So, sufficient time should be spent in developing whatever is used to

arouse interest and lead into the main subject so that the audience can establish a favorable and receptive listening attitude. In addition to stating the central theme, some indication as to how you intend to develop the subject may help the listener in recognizing relationships between ideas as the speaker progresses.

Conclusion of the Talk. Develop the conclusion so that the central and main ideas are clearly reinforced. Audience - interest should be maintained at a high level right up to the last syllable.

Write and Re-write

A paper that is to be published as an article after it is delivered as a speech will involve re-writing at least twice, and perhaps more—first as an article, then as a speech. Re-writing during the preparation of the article allows you to weigh and select words carefully, to cast them into phrases and sentences which will carry the precise meaning you want to convey to your *reader*. If you try to use the written paper as a manuscript from which to speak, however, you may have some difficulty.

Normally, the way we write and the way we speak differ considerably, primarily because of the contrast between a reader's situation and that of a listener at the time each is receiving the information. If a silent reader doesn't understand what is written the first time he reads it, he usually has time to go back and re-read a given sentence, paragraph, or even page before he goes on to the next unit. A listener, by contrast, has no "second chance," so-to-speak. He must get the speaker's meaning immediately because he usually cannot or does not ask the speaker to stop and repeat so that the puzzling sentence or unit can be "re-heard."

This obviously means that a speaker's language must be as simple and concrete as possible, his sentences relatively short, and his organizational pattern easy-to-follow if he is to communicate successfully. If you are going to read your paper aloud, consider re-writing it in the language and style you personally use in speaking, so that you will be direct and conversational in your approach to the audience. Incidentally, you may be surprised how much easier it is not only on you but also on your listeners.

Sharpen Your Speech Delivery

In the actual delivery of the speech there are obviously two major methods available to you, both of which are equally effective if done well. One, already mentioned, is to use the written paper in developing a speech manuscript suitable for easy, conversational, oral reading. The other is to speak from a brief outline or notes.

During the preparation stage of either of these two methods, one way to assure coverage of all the main ideas and supports, and at the same time to find the best way for you to express these ideas aloud, is to develop a good old-fashioned outline in standard form, including Introduction, Body, and Conclusion. If you use the first method of delivery (speaking from a manuscript) it will help you to find and decide upon certain word choices and ways of putting sentences together which will allow you to be conversational and direct with your audience. The resulting style will

make it much easier for you to *feel* and *think* the ideas *as you are reading the words.*

Once you have settled upon the exact wording and sentence structure for the completed speech manuscript, it should be rehearsed aloud word for word, with as much meaning and real feeling behind the ideas as you can get. Continue revisions until you are satisfied that the manuscript will allow you to be yourself.

A tape recorder can be an excellent aid to you, not only is the process of developing the final speech manuscript, but also in improving the way you read it aloud. If you record your practice readings and listen carefully to the playbacks, you will hear many things which will encourage you. You may also hear a few things you might like to change, such as putting more emphasis upon certain important ideas, developing more speaker-interest in parts or even throughout the talk, or sharpening your person-to-person manner of talking while you read—to mention only a few.

If you find it easier to maintain audience interest by speaking from a brief outline or notes, the use of a tape recorder during practice sessions will give you additional help in spotting areas where you may wish to strengthen your own concepts, or perhaps make even better use of your voice in getting the intended meaning across. A few such recording and playback practice sessions can be very rewarding.

"See" Each Listener

During the actual delivery of the talk at the meeting, a speaker needs his own continuous index of "feedback." That is, he *must establish and maintain* definite *eye contact* with as many individuals as he possibly can during the speech, so that each person will feel that *he* individually is being included in the speaker's audience. By this means you can evaluate your own progress and success in getting your thoughts and feelings across and can adjust accordingly as you move along. When visual aids are used, you should be so familiar with their nature and content that good eye contact with the group can be maintained even while working with the aid.

One last word about the speaker's *enthusiasm* both before, and on the day of the talk. You not only should check your visual aids and other materials before the meeting time, you should also prepare yourself psychologically. Your feelings of friendliness and enthusiasm about your subject matter and the opportunity to share it with your peers in this particular group of associates and other professional people must be so vital and intense that they will be infectious to everyone, even those in the back row. Let the group share with you the proper pride you have in your subject, your chosen profession, and in your status as a fellow human being.

A little spontaneous feeling can send a thought a long way.

THE ENGINEER AND THE CLIMATE OF OPINION

SARA RUTH WATSON

Associate Professor of English
Fenn College
Cleveland 15, Ohio

A paper presented to a joint conference of the Humanistic-Social and English Divisions on June 27, 1956, Ames, Iowa.

It was Alfred North Whitehead who revived and popularized the phrase "climate of opinion," first used by him in 1925 in his *Science and the Modern World*—a phrase he had borrowed from Descartes. Then Carl Becker used the term to entitle an essay in which he analyzes the modern climate of opinion by distinguishing four features. (This essay is often included in anthologies and arouses excited comment from students.) Becker's first characteristic of our climate of opinion is that it is in a constant state of change—"Whirl is King," to borrow a phrase from Aristophanes.

His second point is a natural concomitant of the first. Since the world is in motion, we must, in order to explain anything, understand where it came from and where it seems to be going. Consequently an historical viewpoint is essential. Thirdly, we are scientifically minded; we deal with "brute, irreducible facts" rather than abstractions or philosophic ideas. And finally, we are concerned with measurement, with quantity and size.

These last two characteristics mentioned by Becker are the special concern of the engineer; he is the product of this climate of opinion, and in turn helps to form it. Obviously he must assume responsibility for his part. In order to do this he must understand this climate and be aware of its flaws and weaknesses.

Why do science and measurement play so large a role in our society? Why have we become known as a technological civilization? What produced engineering and the engineer? Like true children of our time, we seek the answer in history.

Science—modern science—was born in the sixteenth and seventeenth centuries in Europe. Of all the movement then active, science grew and spread because of its universality. It was Francis Bacon who insisted upon the need to assemble and measure physical data, who thus revived and popularized the inductive method of reasoning. But before much could be done in applied science the abstract sciences of mathematics, mechanics, physics, and chemistry had to advance. Therefore it was not until the eighteenth century that engineering emerged as a science and began to imprint its ideal upon the climate of opinion.

To master man's physical environment and to harness it for his comfort and use became one of the dominant characteristics of eighteenth century thought. I do not think it co-incidental that this idea was coupled, in the eighteenth century climate, with belief in the common man and his perfectibility.

Faith in man, in his capacity for improving his world and himself, found expression in the democratic concepts

which mark the birth of this country. And, as a consequence Yankee ingenuity, American "know-how," American technology—call it what you will—have been trade marks of our culture. The United States has been known pre-eminently for its engineering and technological prowess—and our eminence in these fields has gone unchallenged in the world until very recently.

One example will suffice. At the time of Washington's inauguration as President, building in the United States was on the same technological level as that in Europe. But already fresh, indigenous types of buildings had appeared in the new country. One was the plan of the city hall,—a design that had to fit the needs of a large, representational form of government. Another was the one-family, free-standing dwelling.

A third was the factory—a most significant innovation. In 1793 Samuel Slater had built at Pawtucket, Rhode Island, a new spinning mill whose machines were powered by water. In 1814 Francis Cabot Lowell revolutionized the textile industry by introducing his power loom and by organizing, for the first time, all cloth-making processes within one mill. Its operation marked the beginning in America of mass production, and led directly to the assembly-line, an American invention.

We need not rehearse all the inventions of the nineteenth and twentieth centuries to emphasize the scientific and technological qualities of our climate of opinion. The advances of these sciences have been little short of phenomenal. But as a consequence our society is a materialistic one—with "success" being measured in terms of automobiles, electric kitchens, deep-freezes, and television sets, or, in the case of nations, by the number of jet-aircraft and the size of the hydrogen bomb-pile.

Now, at the time when the scientist and engineer seem to be in control of our climate of opinion, there are signs of revolt apparent in the rise of anti-intellectualism, which takes various forms. The engineer's world is founded upon reason, upon the intellect. Without the abstract sciences, without mathematics and physics, engineering would wither and die. The engineer must have basic principles to work with.

Ever mindful of this need, it behooves him then to oppose anti-intellectualism, which threatens the life of science, and to encourage the growth of abstract knowledge, research in the pure sciences, the pursuit of truth. Anti-intellectualism scorns science because the latter does not cure all of society's ills, because the world does not seem to be a better place—in short, because science has not proved to be the panacea it was hoped it would be.

What are these anti-intellectual movements that seem to be modifying the climate of opinion, threatening the scientific viewpoint? One is a revival of orthodox, evangelical religion—a movement resembling Pietism which, in the eighteenth and early nineteenth centuries appealed to the emotion, to the sentiment of the individual. The appeal here is to a new mysticism, a belief in supernaturalism, an attempt to return to primitive magic. Sects and churches that offer the security of a well-ordered heaven and hell are flourishing.

Another manifestation of anti-intellectualism is the worship of the label "average American." Standard-

ization tends to stifle innovations, individualism, non-conformity. Only the majority is right; minority rights and interests are disregarded. We must beware lest our self-complacency crystallize our whole culture and prohibit growth, expansion, or change.

Standardization also fosters an irresponsibility, a lack of integrity, in the individual. It becomes easy to shuffle off the task of making decisions and judgments, and to escape one's moral responsibility by following blindly the laws and regulations of institutions or government and the patterns and mores of society.

Another aspect of anti-intellectualism has risen from a school of psychology that tells us that man is not responsible for his actions, has no free will and does not "think" or reason. He is the sum total of the variables of his environment. If man is conditioned altogether by his society, and society is wholly responsible for him, conformity—even rigidity—of the social pattern is a necessity, and automation is complete.

Anti-intellectualism bombards science from yet another position. Unfortunately some people assume that knowledge is evil; therefore they resent and fear intellectuals. John Milton tried many years ago to allay this fear, born of the original sin of Adam and Eve, and to demonstrate that knowledge of good and evil must go hand in hand, that the two are inseparable.

Nor is this resentment of learning limited to the illiterate and ignorant. The Philistine who is waxing fat and prosperous wants to maintain the *status quo* and brooks no interference from the intellectual or liberal who might upset it. A distrust of new ideas, of novelty or change, is always to be expected from certain groups of people.

Finally, there are the pseudo-scientists and charlatans, who, with a little learning and no ethical principles or intellectual honesty, bring dishonor upon all intellectual pursuits. These unscrupulous individuals are more readily discovered in medicine and other scientific areas, but they are insidious in any realm of study. Neither quackery nor dilettantism can be tolerated by the sincere pursuer of truth.

These, then, are the forces of anti-intellectualism that seem to be growing in our time. All of us—humanist and scientist alike—have a stake in this battle. We must not regress into a world of black magic; we must persist in pushing inch by inch the cutting edge of knowledge more deeply through the darkness. The scientific method and scientific research are among our finest pieces of equipment.

As educators involved in engineering education, we need to alert the engineer to the dangers of anti-intellectualism, to make him aware of his need for the pure scientist and for the humanist. Then and only then will he have found himself, his place in society, and his significance in the evolution of civilization.

First of all, he must be aware of his dependency upon pure science, and abstract thought. The engineer must have the principle, the hypothesis, the theorem, to serve as the base for the erection of his monuments. Very recently Professor Von Karman stated that the Americans had the "know-how," but the Europeans had the "think-how." Obviously, a society needs both.

Whitehead declared that a "civilization which cannot burst through its

current abstractions is doomed to sterility after a very limited period of progress. An active school of philosophy is quite as important for the locomotion of ideas, as is an active school of railway engineers for the locomotion of fuel." Let us take note of this warning before it is too late.

The engineer's need of the humanist is perhaps less tangible than that for the pure scientist, but is nonetheless real. Those of us working in the liberal arts have witnessed again and again the personal growth of an engineering student who responds to the stimuli of his courses in the humanities. I think, too, that we have erred in overemphasizing the usefulness of these subjects in the pursuit of his career. To be sure psychology, economics, speech and English composition will prove to be of aid to him in his professional life, but these rewards are inferior to the greater one of personal growth. The disciplines of the liberal arts form the complete man, shape the individual personality, nourish the qualities of integrity, tolerance, magnanimity. The report of Dr. Edwin Burdell's committee, "General Education in Engineering", lists the benefits an engineer may derive from humanistic studies, but it puts the personal rewards last—points 5 and 6—which I would place at the top:

5. The development of moral, ethical and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare and to a sound professional attitude;

6. The attainment of an interest and pleasure in these pursuits, and thus the inspiration to continued study.

Notice how closely point five parallels Milton's concept of the educated man: "I call therefore a complete and generous education that which fits a man to perform justly, skilfully, and magnanimously all the offlces, both private and public, of peace and war."

As an educator I would say to an engineering student: know your subject as thoroughly as possible and honor your skill, your "know-how." But beware of anti-intellectualism in its many forms which would destroy the works of science and discredit the scientific method. Recognizing your dependency upon abstract thought, respect and foster the pursuit of knowledge for its own sake, and realizing that you must learn to live with yourself, and with your fellowmen, cultivate the arts and the humanities. I think it significant that perhaps the greatest man in our world is Albert Schweitzer who, like Renaissance man, has succeeded in uniting all these three in one: philosopher and scientist, practicing physician, artist and man of letters.

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OBJECTIVES, CURRICULA, AND RESULTS OF THE CORNELL ENGINEERING PHYSICS PROGRAM

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In order to understand the reasons for establishing the program in Engineering Physics at Cornell and to appreciate fully its nature and objectives, I would like to review some of the thinking that convinced us of the need for a new approach to the training of those students who would one day be needed to take part in a rapidly expanding and intensive era of industrial research and development.

At the close of World War II, some of us on the faculty who had been intimately associated with research and development programs during the war realized that the depth of training in science and the field of materials possessed by those who had been trained in traditional highly departmentalized engineering disciplines would be entirely inadequate to fit them for careers in the industrial research and advanced engineering development of the future. It had become all too clear from the experiences with engineers in the research efforts during the war that the conventional engineering training did not have sufficient depth in mathematics, physics, and chemistry to fulfill the requirements even in the development field. A great deal of this thinking has been well borne out by the course of developments since 1946.

The staggering growth of research and development in this country has completely justified the thinking of 1946. The melding of science and engineering takes place mostly in industrial laboratories and the growth of the industrial laboratories and the products of these laboratories have become a new and constructive force in our present society.

It was evident in 1946 that if the growth of industrial laboratories taking place from 1900 to 1946 should continue, a new type of training to prepare students for industrial research and development would be absolutely necessary in order to supply the future demand. This has already exceeded our estimates, for in the first decade of this century there were only about 50 industrial laboratories, mainly devoted to testing and quality control, employing very few research personnel. By 1920, the National Research Council listed over 300 known industrial laboratories employing approximately 2,500 scientists and engineers and by 1940 the number of laboratories had increased to approximately 2,200 with nearly 60,000 scientists and engineers employed. At the present time, there are more than 3,500 industrial laboratories employing 160,000 scientists and engineers. In addition to the industrial growth there

has been a gargantuan growth in the research and development activities of the federal government. The Department of Defense and the Atomic Energy Commission employ from 75,000 to 100,000 scientists and engineers and spend vast sums of money to keep this country technically strong.

It would appear that at the present time about one-third of the scientists and engineers in the country are engaged in research and development and the growing demands of the civilian economy and defense programs will require an even larger percentage of scientists and engineers. This large increase in the percentage of engineers and scientists required in research and development confirms the wiseness in establishing a program at Cornell which is especially designed for the training of personnel in this rapidly growing field.

There were several reasons why it was necessary to introduce an entirely new five-year program rather than to attempt modifications of the curricula existing in engineering departments. A few of these may be mentioned. It became obvious at once that it would not be possible to inject the necessary amount of physics, mathematics, chemistry, and courses in the constitution of materials in the carefully guarded credit hours of regular engineering courses typical of each engineering discipline. It would have been impossible to remove the typical barriers that exist in educational institutions which tend to divide the province of the pure sciences and engineering. It was necessary to start anew in order to achieve a high degree of integration in the sciences given in the College of Arts and Sciences and the appropriate courses in engineering given in the College of Engineering. Therefore, in 1946 an entirely new program was established which was called by the rather undescriptive name of Engineering Physics.

Objectives

The type of training which is best suited for a person going into industrial research and advanced engineering development is a training that establishes a student's competence in the basic sciences but necessarily bridges the gap between a student trained in pure science or professional engineering. Consequently, the type of training is somewhere between that of a pure scientist and a conventional engineer. This means that the program must provide a student with a thorough understanding of the laws and principles which account for the behavior of natural phenomena and a commanding analytical skill and at the same time provide him with the means and techniques of applying this knowledge to evolve new engineering machines, devices, and systems.

In addition, the program must develop an appreciation and understanding of the properties of materials from the constituent atoms and molecules to the bulk physical, electrical, and chemical properties. The training must also in some way instill the spirit of creativeness and discovery in the student which is the essence of research and development. Very importantly, it must do this in a five-year period so that a student earning the Bachelor of Engineering Physics degree can step out into industry and begin making a definite contribution in the field of industrial research and development.

Perhaps with this background, I can briefly state the objective of the Cornell Engineering Physics curriculum.

It is to provide a training which thoroughly integrates the basic knowledge and analytical background of the physicist and to a certain extent the applied mathematician and chemist with an adequate knowledge of the physical constitution and properties of materials and the technological practices and methods of engineering.

There are five important factors which must be properly brought together in order to achieve success in meeting the technical objectives of such an educational program and at the same time provide the means by which a student can develop creativeness, sound technical judgment, the spirit of independent accomplishment, and a keen sense of the correctness of things. These factors are: a live and technically creative faculty with industrial research experience, a curriculum which is constantly in step with technical progress, able students well selected for interest in research or development and definiteness of purpose, an associated graduate research program actively led by the faculty with which students can come into intimate contact, and an administration which is capable of providing a high degree of integration of the basic sciences with engineering, the subject-matter of the curriculum itself, and the contacts of students and faculty.

The Curriculum

The main features of the curriculum were decided upon after a long and penetrating study of the subject-matter that would be required to give students the best foundation for general research and advanced development work in a variety of fields. The result of the study indicated that the subject-matter would fall under three main categories, namely, the fundamental sciences of physics, mathematics, and chemistry; the constitution of materials (beginning with the study of atomic and molecular structure through that of liquids and solids) in such a way that wherever possible the electrical and mechanical properties of materials could be connected with their particular atomic constitution; and various subject-matter from a wide range of professional engineering fields. From the very beginning a great effort was made to erase any boundary lines between the various scientific subjects given in the College of Arts and Sciences and the engineering subjects given in the College of Engineering. A constant effort throughout the entire years of development of the program has gone into the integration of the various subjects in the sense that the work in physics and chemistry should use the maximum amount of mathematics the student has acquired at any one time and other more advanced subjects should be consciously built on preceding technical subjects. It was always considered a point of strength that the various subjects were taught by authorities on the particular subject no matter where they were located in the university. It was considered a good thing for the student to develop to some extent for himself the connections of mathematics with the sciences and the sciences with the work on materials and the connection of these with engineering subjects.

A curriculum committee has existed from the very inception of the program and has been active in making modifications of the program whenever weaknesses developed or whenever it became apparent that new

subject-matter should be introduced to keep up with modern technical developments.

A general view of the subject-matter content of the Engineering Physics curriculum which has evolved after ten years of study and experience is shown in Table 2. The subjects are listed under four main categories, fundamental science, applied science, engineering, and social or humanistic studies. The principal subjects in each category are listed and the year in which each is taken is shown.

The curriculum in detail is given in Table 1.

Table 1—Engineering Physics Curriculum

		Credit Hours	Contact Hours Lec. Rec.	Lab. Comp.
TERM 1	Mathematics 161 or 181, Analytic Geometry and Calculus	3	3	0
	Physics 115, Mechanics	3	3	2½
	Chemistry 105, General Chemistry	3	3	2½
	English 111, Introductory Course	3	3	0
	Engineering 3117, Drawing and Descriptive Geometry	2	0	5
	Liberal Elective	3	3	0
	Total	17		
TERM 2	Mathematics 162 or 182, Analytic Geometry and Calculus	3	3	0
	Physics 116, Wave Motion, Sound, and Heat	3	3	2½
	Chemistry 106, General Chemistry	3	2	3
	English 112, Introductory Course	3	3	0
	Engineering 3118, Drawing and Descriptive Geometry	2	0	5
	Engineering 3403, Fundamentals of Machine Tools	1	0	2½
	Elective	3		
	Total	18		
TERM 3	Mathematics 163 or 183, Analytic Geometry and Calculus	3	3	0
	Physics 117, Electricity and Magnetism	3	3	2½
	Engineering 1151, Statics	3	3	0
	A modern foreign language	6	2	6
	Engineering 6110, Casting, Working and Welding of Metals	2	1	2
	Total	17		
TERM 4	Mathematics 201, Elementary Differential Equations	3	3	0
	Physics 118, Electricity, Magnetism, and Light	3	3	2½
	Chemistry 402, Introduction to Physical Chemistry	3	3	0
	Physics 208, Physical Mechanics and Properties of Matter	3	3	0
	Engineering 4983, Basic Electrical Engineering	4	3	2½
	Total	16		

In addition to these courses, students, must satisfy the university's requirements in military training and physical education for the first four terms.

		Credit Hours	Contact Hours Lec. Rec.	Lab. Comp.
TERM 5	Mathematics 613, Methods of Applied Mathematics	3	3	0
	Physics 225, Electricity and Magnetism	3	3	0
	Engineering 8121, Thermodynamics and Kinetic Theory	3	3	0
	Engineering 4116, Electric-Circuit Laboratory	3	1	3
	Engineering 1153, Mechanics of Materials	3	2	2½
	Elective	3		
	Total	18		
TERM 6	Mathematics 614, Methods of Applied Mathematics	3	3	0
	Physics 242, Analytical Mechanics	3	3	0
	Engineering 8122, Thermodynamics and Kinetic Theory	3	3	0
	Engineering 4121, Electron Tubes and Circuits	4	2	5
	Elective	3		
	Total	16		
TERM 7	Mathematics 615, Methods of Applied Mathematics	3	3	0
	Physics 243, Atomic and Molecular Physics	3	3	0
	Engineering 1201, Engineering Materials	4	3	2½
	Engineering 4122, Electronic Circuit Elements	4	2	5
	Elective	3		
	Total	17		
TERM 8	Mathematics 616, Methods of Applied Mathematics	3	3	0
	Physics 254, Electronic Properties of Solids and Liquids	3	3	0
	Physics 210, Advanced Laboratory	3	0	5
	Chemistry 416, Chemical Bonding and Physical Properties of Organic Molecules	3	3	0
	Elective	3		
	Total	15		
TERM 9	Physics 210, Advanced Laboratory	3	0	5
	Engineering 1202, Advanced Materials	3	3	0
	Engineering 8051, Project	3		
	Electives	9		
	Total	18		
TERM 10	Physics 258, Mechanics of Continuum	3	3	0
	Engineering 8052, Project	3		
	Electives	12		
	Total	18		

Table 2

SUBJECT MATTER	HOURS	TERM 1 2	3 4	5 6	7 8	9 10
FUNDAMENTAL SCIENCE						
Mathematics	24					
Physics	33					
Chemistry	12					
APPLIED SCIENCE						
Engineering Mechanics	6					
Strength of Materials	3					
Thermodynamics and Kinetic Theory	6					
Engineering Materials With Laboratory	7					
ENGINEERING PRACTICE						
Drawing and Descriptive Geometry	4					
Fundamentals of Machine Tools	1					
Metal Casting, Working, Welding	2					
Electric and Magnetic Circuits	4					
Electric Circuit Laboratory	3					
Electronic Tubes and Circuits with Laboratory	8					
TECHNICAL ELECTIVE AND RESEARCH PROJECT	18					
SOCIAL AND HUMANISTIC STUDIES						
English	6					
Foreign Language	6					
Elective	18					
MISCELLANEOUS ELECTIVES	9					
TOTAL	170					

It will be noted that a considerable number of liberal studies in other than technical fields are to some extent mandatory and elective.

It will also be noted that each student devotes a considerable amount of time to a project during his fifth year. Each student is required to complete a project of a semi-research nature in any approved technical area. These projects are directed by a faculty member in the particular field of his interest. By this means it is hoped that the student will become initiated into the spirit of independent research and achieve, by close association with a productive faculty member, some degree of creativeness. Throughout the whole progam, a close contact between student and faculty is attempted, with all appropriate counseling. The senior projects are done in a variety of fields and in order to give some idea of the nature of these projects, a typical list of those completed during the past academic year is given in Table 3.

Table 3—Typical Senior Projects

	Department
Study in Push-pull Magnetic Amplifiers	Electrical Engineering
A Study of the Effects of Low Temperatures on the Sensitivity of Photomultiplier Tubes	Engineering Physics
Longitudinal Stability Calculations on Mooney Mite Airplane	Aeronautical Engineering

A Study of the Dielectric Properties of Luminescent ZnS	Engineering Physics
Signal Detection in the Presence of Noise	Mathematics
Investigation and Construction of Linking Apparatus for a Two-Antenna Radio Frequency Interferometer	Electrical Engineering
Matching and Measurement of a 3620 mc Receiver	Electrical Engineering
Improvement of Signal to Noise Ratio for Application to Work Being Done on Ionosphere Study	Electrical Engineering
Binding Energy of Carbon in Iron Using Torsional Pendulum	Physics
An Electronic-mechanical Analog Computer for Computation of Refraction of Radio Waves Entering the Atmosphere from Extra-terrestrial Sources	Electrical Engineering
Design of an Advanced Laboratory Luminescence Experiment	Physics
Study of Magneto-Hydrodynamic Shock	Aeronautical Engineering
Stress Distributions in Orthotropic Strips	Electrical Engineering
Design and Construction of a Phase Angle Comparator	Electrical Engineering
A Study of Internal Friction in Single Crystals of Magnesium	Engineering Physics
A Study of Methods for Increasing Receiver Sensitivity in Radio Astronomy	Electrical Engineering
A Device for Audiopresentation of Electroencephalograms	Electrical Engineering and Psychology
Study of Gasdynamics	Aeronautical Engineering

The Engineering Physics Department took the leadership in developing a program of nuclear technology which was in the nature of an option which would be available to all qualified undergraduate students in the Engineering College who were interested in pursuing work in the nuclear energy field. This program is an outgrowth of the extensive research and graduate programs in nuclear sciences developed at Cornell over many years and represents recognition by Cornell of the great need for trained men in nuclear technology and of the desire of an increasing number of engineering students to prepare for work in this field. The courses which are included in this option are as follows:

Table 4—Nuclear Technology Option

	Course Number	Credit Hours	Term
Atom, Nuclear, and Electron Physics	P 214	3	8
Nuclear and Reactor Physics	8311	3	9
Nuclear Measurements Laboratory	8351	2	9
Advanced Heat Transfer	ME 3665	3	
	or ChE 5505	2	
	(or equivalent)		10
Special Topics in Nuclear Engineering	5760	2	10

Facilities and Location

During the past ten years the center of the Engineering Physics Department has been located in the same building as the Department of Physics which in turn is located close to the other science departments. In this way the students came into close contact with the fundamental sciences but were urged to take part in projects

and activities throughout the Engineering College in order to help them bridge the gap between the sciences and the practice of engineering.

In a certain sense this arrangement pointed out the fact that, in these days when engineering must depend more and more on the basic sciences and less and less on art and pragmatism, the Engineering Physics program established a strong connecting link between the basic sciences and engineering. The Engineering Physics Department had ready access to all of the Physics shops and other technical facilities. As the program evolved, a very substantial electron microscopy and electron diffraction laboratory was set up which served as a center of such activities for the whole university campus for both undergraduate and graduate instruction. This in itself acted as a strong cohesive force.

At the present time, the rapid expansion and demand for people trained in Engineering Physics requires additional space for the future.

The Faculty and Administration

The faculty members who would have control over this new curriculum were carefully selected for their experience in industry, their first-hand knowledge of research, their productivity and their success as teachers, and their ability to represent different technical disciplines. Only a few of the faculty members were appointed directly to the Department of Engineering Physics. The remainder maintained their connection with their home departments or schools. Thus faculty members with a prime interest in the new curriculum were selected from departments of Physics, Mathematics, Electrical Engineering, Mechanics and Materials, and the Graduate School of Aeronautical Engineering. The degree of integration of all the subject-matter with the help of this faculty was remarkable and it was through the efforts of this faculty that the program has been such an outstanding success.

Administratively, the Department of Engineering Physics is placed within the College of Engineering and the director of the department has the same status as the director of any of the engineering schools within the college such as the School of Electrical Engineering. From the inception of the department until now, the director has also been the chairman of the Department of Physics who is responsible to the Dean of the College of Arts and Sciences. In this way it was possible to achieve the maximum degree of cooperation between the two colleges and to induce a strong sense of mutual responsibility for the successful operation of the program. After July 1, the administration of the department will be separated from that of the Department of Physics.

Results of the First Decade

In spite of the fact that this course represents the most rigorous technical course in the university, the student demand for it has steadily increased. The entering freshman class for next year has reached 56. The total enrollment in the five-year curriculum as of last fall was 172. This amounts to nearly two-thirds of the enrollment in Civil Engineering, one-half of that in Chemical Engineering, about one-half of that in Electrical Engineering, and about 30% of that in Mechanical Engineering. Of the total enrollment in the College of Engineering, about

10% is in Engineering Physics. Considering that about 40% of engineers and scientists go into industrial research and development, our program should be increased still further subject to the availability of qualified students.

It has been amply demonstrated that students acquiring the Bachelor of Engineering Physics degree have a great deal more knowledge of physics and mathematics than the four-year physics majors in the College of Arts and Sciences. This is due to the fact that they commit themselves to the program when they enter the university instead of two years later and in addition they are able to assimilate greater knowledge and technical facility because of the highly integrated nature of the more rapidly moving curriculum. Also, they have an extra year. It is at this point that one of the important objectives of the program is achieved, namely, that students completing the five-year course can go into industry immediately without further training and begin to make a significant contribution to the research or development program.

About one-half of the graduates have been readily accepted into leading graduate schools to major in a variety of disciplines including physics, applied mathematics, aeronautical engineering, and the like. Many have received good fellowships, and one received a Fulbright award to work at the University of Göttingen, Germany. It is expected that many of those who will obtain advanced degrees will find their way into industrial or government research. The remainder go into the Armed Services. The decisive and apodictic test of the success of the program rests entirely on the ability of the graduates to make positive contributions to the research and development effort of the country and the degree to which they are prepared to do further graduate work.

Such reports as we have received from the various companies employing the graduates, the students themselves, and discussions with company representatives seeking to employ them, furnish striking evidence of the value and success of this program in preparing students for outstanding careers in industrial research and development.

Those of us who have had the responsibility for the development of this new program of training are convinced that a course fulfilling the objectives discussed above constitutes the best way to prepare students for careers in research and development. It is far easier and quicker to reach these objectives by establishing a completely new program than by modifying or making over existing curricula in traditional engineering disciplines. It would be a very long time before the requisite amount of basic science and materials could be properly injected and integrated in courses which have been in operation for a long time. It is doubtful whether this method of procedure would be advisable in any case.

It seems abundantly clear that programs of the type discussed here will be established in greater numbers and their enrollments will become comparable with those of other engineering departments. This will be necessary, indeed, to staff our research and development activity of the future if we are to meet effectively our very strong international competitors.

STATISTICS IN ENGINEERING

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Since 1924, when W. A. Shewhart's classic paper, "Some Applications of Statistical Methods to the Analysis of Physical and Engineering Data," appeared in the *Bell System Technical Journal*, the application of statistical methods in the industrial field has advanced rapidly. Evidence is the tremendous increase in the number of articles concerned with industrial applications of statistics appearing in both mathematical and engineering journals. That the statistician and the engineer have joined forces in order to solve many of the problems of research and production is a considerable step forward. Let us keep in mind, however, that it is only a step, and not the complete journey.

Several statistical tools are being used today by industry, but of these, two in particular have received much attention and are the best known. To many people, they are synonymous with industrial statistics. These are: statistical quality control charts, and sampling inspection plans.

The essential basis of the abovementioned techniques is the chance or random variability inherent in all such repetitive production processes. Apart from chance variation, it is evident that machines and people undergo "wear and tear" due to use, and hence uniform results should not be expected from each operation. We should, however, expect results which vary in a stable pattern (commonly called "constant-cause" variation) and if our observed data do not conform to this pattern, we attempt to locate and correct the cause of this nonrandom variation.

Statistics for Industrial Experiments

Many other statistical techniques are now beginning to be adopted by research and production workers in industry. To name just a few of these, we may consider: regression and correlation, chi-square analysis of contingency tables, and analysis of variance. It gratifies the statistician to know these tools are becoming more widely appreciated. Perhaps the greatest single step forward was made when engineers saw the possibilities in using analysis of variance techniques in their work, for this tool opens the way to a more complete study of experimental design.

The design of industrial experiments is an area to which attention has only recently been turned. This is not to say it is the least important of the techniques available to the engineer and research worker. On the contrary, it is probably the most important. However, it is also one of the more difficult and has been relegated to a back seat in the development of industrial statistics. The statistical design of experiments has progressed far in other fields, notably in agricul-

ture, and the statistician should urge engineers to use these developments in the industrial field. Experimentation and research are taking a larger place in the industrial picture every day; thus the use of properly designed experiments is to be desired more than ever.

A statistically designed experiment may be very simple, i.e., the comparison of two sample means, or it may be decidedly complex, as in the case of incomplete block designs and fractional replications. The important thing is that if the problem is presented to a statistician *before* the experiment is performed, the experiment can often be set up so that maximum information is obtained on the factors being examined. All too often the experiment is performed, data recorded, and *then* the statistician is asked, "What do these data tell me?" and, much to the experimenter's dismay, the answer is quite often, "Very little!"

That some sort of design is necessary before any experiment is performed can be illustrated by determining the effect of gasoline and oil additives on carbon and gum formation in automobile engines.[1] The problem involves the testing of 20 additives in combination with a "control" gasoline and oil mixture on 80 similar engines. How can one design the experiment most efficiently to determine the performance of the various additives? We note that in our example the factors to be tested have already been decided—this is usually one of the first problems in designing a good experiment. Other questions which should be asked at this stage are:

(1) How many tests should be run at each different combination of experimental conditions?
(2) How will the data be analyzed?
(3) What general conclusions can one validly draw from data obtained under the chosen experimental design?

Fortunately, we find that the most efficient designs are usually capable of simple analyses. This is one very important reason why the statistician should be consulted in the early stages of any proposed research project—he can often supply a fairly simple design which is both efficient and economical.

Experimental Analysis

A frequent stumbling-block in the way of using statistical design of experiments in industry has been the feeling that too much theory is involved. This is not necessarily so. The major part of the theory used in the design of experiments is that needed for analysis of variance techniques (1, 2, 4), that is, some understanding of the *normal* distribution, coupled with a few ideas concerning linear combinations of random variables and the general concept of testing hypotheses. This, then, is not as forbidding a picture as often advertised. The quality control engineer who has examined some analysis of variance tables will have noticed the close connection between these and the more familiar quality control charts.

For example, the variation "among groups" is another way of presenting the familiar $\overline{X}$-chart and the variation "among individuals within groups" is

[1] Projects and Publications of the National Applied Mathematics Laboratories: April through June 1949; p. 79.

an alternative presentation of the R-chart. In both control charts and analyses of variance, the concept of a normal distribution is employed. In both, a test of an hypothesis is performed: in control chart technique the hypothesis of equal means is rejected when a point plots outside the control limits; using analysis of variance methods, the same hypothesis is rejected when the ratio of two mean squares (denoted by F) exceeds some pre-assigned value.

To illustrate the type of procedure known as analysis of variance, let us consider a series of experiments reported by Leavitt (3). A number of laboratories undertook a cooperative experiment to examine the mean compressive strengths of plastic mortar cubes tested seven days after fabrication. For our purposes, we shall examine the data made available by just one laboratory. Three cubes were made from the same mixture batch on each of sixty successive days. Every effort was made to prepare the samples under as uniform conditions as possible.

The following is a representative analysis of the experimental results:

ANALYSIS OF VARIANCE: AMONG AND WITHIN BATCHES OF MORTAR
(The original observations were in lbs./sq. in.)

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	Expected Mean Square
Among batches on successive days	59	5,938,763	100,657	$\sigma^2 + 3\sigma_B^2$
Among cubes in the same batches	120	510,360	4,253	σ^2
Total	179	6,449,123		

The larger the critical value of F, the less risk we run of erroneously claiming the variation among day-to-day batches is excessive. For this particular problem, 1.65 is an appropriate value. The significantly large value of $F = 100{,}657/4{,}253 = 23.67$ (much greater than 1.65, our pre-assigned value) leads us to the conclusion that this particular laboratory could not make uniform mixes from one day to another.

Similar results were obtained on examination of data from the other cooperating laboratories. That is, we reject the hypothesis that a laboratory can mix mortar on several occasions which will be sufficiently uniform with respect to compressive strength, and there is a very small probability (much smaller than 0.001) that we have erred in making such a decision. In passing, we might mention that the differences among laboratories were even more significant.

The analogy between the analysis of variance test and the control chart for means ($\overline{X}$-chart) is as follows: if we plot the mean compressive strength of each batch of three plastic mortar cubes on the appropriate $\overline{X}$-chart, we would find points "out of control." Thus we would reach the same conclusion as by the analysis of

variance technique, namely, the rejection of the hypothesis of a uniform process.

The theory met in the design of experiments, then, is not new; only the terminology is different. Once these new terms are thoroughly understood by the person using industrial statistics, the possibilities for a fruitful use of experimental design techniques present themselves with astonishing rapidity.

Statistical Training for Engineers

Having seen that the proper design of statistical experiments is of prime importance in the industrial field as well as in the research laboratory, the problem then presents itself as to how best to provide the necessary training in statistical methods for the engineer and the research worker. In the case of the research worker (who generally has spent considerable time in academic study), this may be satisfactorily handled through instruction while still in college. However, the case of the engineer is not so easily settled. One finds it necessary to distinguish between engineers who are already employed and have little or no time to attend classes conducted by the universities, and students in the various engineering colleges throughout the country.

The first of these two groups has learned much in recent years through attendance at various clinics and short courses on statistical quality control and sampling inspection. Some find time to attend regular night classes given by the extension services of many colleges, and many learn through home study and on-the-job training. However, in most cases, the range of items studied is of necessity limited and those principles and methods necessary to a clear understanding of the design of experiments are not learned.

This deficiency can be overcome by giving adequate statistical training to the engineer while he is still attending college. At Montana State College, the Department of Mathematics and the Statistical Laboratory, in cooperation with the Division of Engineering, are in the process of developing a program in statistics for the engineering student. This program is expected to give a thorough training in basic statistical methods and the fundamentals of experimental design as well as in the more well-known and popular fields of statistical quality control and sampling.

It is obvious to us, familiar as we are with the heavy burden of material already well established in most undergraduate engineering curricula, that the addition of several courses in statistics presents quite a problem. On the other hand, a student taking graduate work towards an advanced degree in one of the engineering fields has an excellent opportunity to become adequately trained in statistical theory and methods by choosing a minor in statistics. The undergraduate, though, is our main concern. *It is my belief that at least one basic course in statistics should be included in all undergraduate engineering curricula.* Other statistics courses could be suggested as "electives."

If a basic course in statistics is introduced at an early stage into all undergraduate engineering curricula, the engineer will at least become acquainted with the statistical approach as well as with statistical terminology. This will better prepare him to handle

some of his other courses. Second, it will aid him immensely in understanding many of the articles now being published in the engineering journals. Third, it will give him a basic knowledge necessary to a better appreciation of many engineering problems.

A study of requests for engineering personnel soon points out that statistical training is very much in demand. Engineering schools that are sensitive to such demands of industry should periodically revise their programs to fit more closely the needs of our changing technology.

Let us hope that the time is not too far distant when at least one statistics course will be included in all accredited undergraduate engineering curricula.

Bibliography

1. Cochran, W. G. *Some Consequences When the Assumptions for the Analysis of Variance Are Not Satisfied,* Biometrics Bulletin, Vol. 3, No. 1, March 1947.
2. Eisenhart, C. *The Assumptions Underlying the Analysis of Variance,* Biometrics Bulletin, Vol. 3, No. 1, March, 1947.
3. Leavitt, W. H. *A Study of Plastic Mortar Cubes,* Proc. of Amer. Soc. for Testing Materials, Vol. 37, p. 321, 1937.
4. Ostle, Bernard. *Statistics in Research.* The Iowa State College Press, Ames, Iowa. 1954.
5. Projects and Publications of the National Applied Mathematics Laboratories, A Quarterly Report, April through June, 1949.
6. Shewhart, W. A. *Some Applications of Statistical Methods to the Analysis of Physical and Engineering Data.* The Bell System Technical Journal, January, 1924.

GRADUATE PLASTICS PROGRAM FELLOWSHIPS

Princeton University has made available fellowships for a curriculum of graduate study and fundamental research in plastics, leading to a Master of Science degree in engineering. Instruction covers properties, evaluation, production, fabrication, design, and application of materials, as well as the chemistry of plastics. The program is particularly suited to chemical, electrical, and mechanical engineers, and to chemists and physicists.

Applicants for the fellowships, which carry stipends of from $1500 to $2100 plus tuition and fees, must hold the Bachelor's degree in engineering or physical science from a recognized institution and must meet the general admission requirements of the Princeton University Graduate School. Further information can be obtained from Louis F. Rahm, Director, Plastics Laboratory, 30 Charlton Street, Princeton, N. J.

AUTOMATIC CONTROL SYSTEMS — THE UNIFICATION OF ENGINEERING

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A paper presented at the joint conference of the Mechanical and Electrical Engineering Divisions on June 28, 1956, Ames, Iowa

The term automatic control system is an outgrowth of the more specialized word, "servomechanism." The latter was probably first used by Dean H. L. Hazen of MIT in his two companion papers that appeared in the *Journal of the Franklin Institute* in 1934. The name servo comes from the Latin word "servus" meaning servant or slave, and mechanism from the Latin word "mechanismus" meaning machine. Thus, a servomechanism is a slave-labor machine—one in which large amounts of power can be precisely controlled.

In the years before World War II, the design of servomechanisms was an art that was based on a few isolated facts tempered, of course, by the designer's experience. This resulted in much "cut and try" engineering, with varying degrees of success. During World War II certain groups, notably those at the Radiation Laboratory and Bell Laboratories, were called upon to develop servomechanisms to meet a number of military requirements. As a result of these concentrated efforts, the design of feedback control systems advanced from an art to that of a science, based principally on the work of Bode, Draper, Hall, Hazen, MacColl, and Nyquist.

With the exception of the work by MacColl, the theory developed was a linear one, that is, based upon the solution of linear differential equations. In the past ten years, work in feedback control systems has been directed primarily toward nonlinear system analysis, system optimization, and sampled data systems.

Progress Rapid

To illustrate this forward movement, a decade ago the word servomechanism was popular usage in literature describing radar antenna and gun positioning control systems. Since then, the word servomechanism has been dropped by most professional societies and has been replaced by either the term "feedback control system" or "automatic control system." The latter term has been gaining in popular usage, since it more nearly describes the modern closed-loop system, which may be a feedforward system as well as a feedback system. The change in the name from servomechanism to automatic control system was brought about by the fact that the same mathematical techniques developed for radar positioning systems can be used with slight modification to analyze voltage regulators, electronic amplifiers, or speed and process control systems. In general, it can be applied to any linear system where automatic control is desired.

Inspection of engineering college announcements over the past fifty years reveals an ever-broadening engineering curricula. From what was a single branch of study in engineering at the turn of the century, most engineering curricula have been changed to include a host of fields of specialization at the present time. This specialization has been necessary because of the ever-increasing complexity of our industrial sciences, which in turn has demanded engineers trained in special analytical and design techniques. In addition, it has been necessary for them to become familiar with specialized test and measuring equipment. Most engineering colleges are now turning out graduates who have a broad background in science and mathematics, but who in addition, are reasonably proficient in their field of specialization.

Examination of a piece of modern industrial or military equipment will reveal electronic, electromagnetic, hydraulic, pneumatic, and mechanical components interconnected into a physical complex. Unless an engineering student is given a course in automatic control systems, he is likely to forget about the *systems* aspect of a piece of equipment when on a project and concentrate on the engineering of a particular component. In general, designs involve the most favorable use of material, energy, or weight.

Experience has shown that while it may be essential for individual components to be of optimum design from a cost, material, or energy standpoint, one finds that interconnecting a group of components optimized in this way, will in general, result in a system that is not optimum from a dynamic point of view. At the present time greater and greater emphasis is being placed on the dynamic behavior of modern control systems, and applications are continually arising which demand the use of high performance systems. It is therefore essential that the present engineering graduates have a course in automatic control systems—a course in which the primary emphasis is placed on analyzing a complete system from a dynamic viewpoint.

A control system may involve many different types of components, depending upon the physical situation that is to be controlled. In order to analyze all of the system components many of the isolated principles discussed in previous departmental courses are brought together in a single lecture. The student gets a good review of physical fundamentals and at the same time sees that the same differential equations can describe the operation of an electrical, mechanical, or hydraulic component, or even a complete system.

To pursue the study of systems in any detailed fashion, however, a student must be able to write a differential equation relating the components of the system and have at his command mathematical techniques that will lead to the solution of these equations. In the case of linear systems, a student should be familiar with the Laplace and Fourier transformations, have a general knowledge of functions of a complex variable, and in addition, when dealing with nonlinear systems, should be familiar with phase-space analysis. Since these topics are not covered in the undergraduate curricula of some colleges, a comprehensive treatment of servomechanisms will often be found only as a graduate course.

First Graduate Course

Presupposing that the average graduate student has had a course in the Laplace transformation and functions of a complex variable, the first course in automatic control systems should involve the teaching of feedback concepts. This is normally accomplished by treating first an idealized second-order system with viscous friction damping. This system in turn is then modified with the addition of error-rate damping, integral control, and tachometer feedback, and in each case the modified system is studied.

Simultaneously, these idealized systems are studied in the laboratory on a differential analyzer, and in this way the student is introduced to the analog computer as a helpful tool. He should then be introduced to a physical system and considerable time should be spent on methods used to obtain mathematical equivalence of physical components. Because a student may later be confronted with all types of systems, it is desirable to have examples with varied types of electrical, mechanical, and hydraulic components. At this time the concept of a transfer function can logically be introduced, and can be extended to show how the over-all open-loop and closed-loop transfer functions of a system can be obtained. It is now desirable to develop the Nyquist Stability Criterion in its most general form, and compare it to the Routh-Hurwitz Stability Criterion. The advantages of using the Nyquist diagram to study closed-loop response should now be discussed.

Because it is a tedious job to calculate the points on the locus of a Nyquist diagram, the Bode diagram should be presented as a rapid method of obtaining the Nyquist values. Most electrical engineering students will be familiar with Bode and Nyquist diagrams as they apply to electrical circuits. However, it may be new material for the non-electrical engineering or applied mathematics student. Methods for modifying the closed-loop sinusoidal response should now be discussed. At this point the student has all the basic concepts and techniques available for sinusoidal analysis of feedback control systems and it is now a matter of practice for him to become proficient in analyzing and compensating single-loop feedback control systems.

In order that a student may become familiar with some of these physical systems, it is desirable that a single-loop control system be analyzed in the laboratory in the following manner:

1. Determine the differential equation relating each of the components in the system.
2. Experimentally measure the constants determined in 1.
3. Using the equations obtained in 1 and the constants from 2, calculate the performance of the system for step and ramp inputs of position. Determine the response of the system for sinusoidal inputs.
4. Study closed-loop response of complete experimental system.
5. Using the differential equations or transfer functions obtained in 1, simulate the experimental system on the differential analyzer.
6. Compare the results obtained in parts 3, 4, and 5.

The above material has been satisfactorily covered in a one semester three credit-hour course containing two lectures and one four-hour laboratory period per week.

Second Graduate Course

With the basic concepts obtained in the first course firmly established, the emphasis in the second course is on the synthesis of a system to obtain a prescribed closed-loop response. The approach is more from a circuit synthesis standpoint, in which the closed-loop performance plus a fixed transfer function is prescribed, and a series or parallel transfer function must be determined in operational form. Once the compensating transfer function has been obtained in a physically realizable operational form, it can be converted to a physically realizable network using the circuit synthesis procedures of Cauer, Foster, and Guillemin. This, of course, presupposes that the students are familiar with these techniques. It is possible to present some circuit synthesis techniques at this point in the course by restricting treatment to R-C networks.

Whereas in the first automatic control course, systems were studied only from a frequency response standpoint, in the second course attention is focused on the location of the open and closed loop zeros and poles in the s-plane, which allows the designer to study both the transient and steady-state behavior of a system in a more direct fashion.

Attention should now be turned to the operation of automatic control systems that are subjected to statistical inputs. Discussion of correlation functions and spectral density functions are introduced, along with a discussion of minimizing the rms. error in the presence of noise. These topics serve also as useful concepts for the study of sampled-data systems, which logically follow. At this point in the course the z-transform and its application to the study of sampled-data systems should be introduced. The stability criteria previously developed for continuous systems, such as the Nyquist and Routh-Hurwitz Criteria should be extended to the $F(z)$ and z-plane, respectively. Simple examples of compensation of sampled-data systems in the z-plane can now be treated. By covering the above material, the student should have a reasonably complete understanding of linear control systems. It should also bring him reasonably close to the frontier of linear control systems as they exist at the present time.

Non-Linear Systems

The subject of nonlinear systems can be logically approached by first treating nonlinear systems that contain small nonlinearities. One method of studying systems under such conditions is to use describing functions. Although at the present time describing functions of most of the commonly encountered nonlinearities have been developed and are available in technical literature, the technique of obtaining the describing function for any nonlinearity should be discussed.

Once this technique is mastered, methods for determining the stability of closed-loop systems containing such functions should be considered, and consideration should be given to the methods of linear compensation commonly employed. The student should now be introduced to the phase-space method of analysis that frequently is used in the analysis of nonlinear systems, and which is valid for all types of nonlinearities.

While there is insufficient time to develop the field of nonlinear mechanics in great detail, it is possible to apply this method of analysis to many

of the commonly encountered nonlinearities, such as the operation of a relay servo that contains hysteresis, dead-space, etc. The final topic to be discussed is the insertion of nonlinear functions in a normal linear control system to improve its operating characteristics. While no formal laboratory exists for this course, many of the systems are demonstrated on the differential analyzer.

While time does not permit many practical problems to be discussed in detail, experience has shown that a student can readily grasp the design details much easier than the various concepts involved in a comprehensive coverage of automatic controls.

Undergraduate Instruction

If we presuppose that every engineering student should have a course in automatic control systems before he graduates, and, since he may not have had any of the above mentioned mathematics courses, he can still achieve a reasonable understanding about the principles that govern the operation of systems by having more emphasis put on the concepts that govern the operation of these systems and less on the mathematical rigor. Since most literature dealing with control systems at the present time uses operational mathematics, the student should be first introduced to this subject and study the way in which it can be used to solve linear differential equations. This material should then be extended to include methods for obtaining the differential equations of control systems.

The closed-loop concepts can now be introduced with a study of an idealized second-order system, when subjected to step inputs of position and velocity, and sinusoidal inputs. At this point the concept of a transfer function can be logically introduced, and it should be followed by a discussion of the way in which a number of interconnected transfer functions can be combined in order to give the open and closed loop response of the system. The Nyquist and Routh-Hurwitz Criteria as methods of determining the stability of systems should be discussed. Once a student has gained an understanding of these methods for determining stability, the concept of relative stability can be readily indicated using the Nyquist diagram. Methods of changing the gain and phase of the open-loop function by the addition of compensating networks should now be considered. Since this course is not considered to be a design course, the treatment of compensating networks should be relatively brief. Rather, it should be considered to be a terminal course for these students where it is desirable to indicate that the concepts developed can be applied to a wide range of physical systems. This can be accomplished by analyzing such diversified systems as an electronic voltage regulator, a positional control system, and a heat control system.

An accompanying laboratory course should include experimental models of the above systems, along with a differential analyzer for simulating idealized second-order systems.

The above material has been satisfactorily covered in a four-credit hour course, containing three lectures and one four-hour laboratory per week.

Industrial Training

Teaching the first course in automatic control systems as an evening course normally involves some modification of this material. Experience

has demonstrated that the average night school student is an engineering graduate who is employed in a position where it is essential that he learn something about automatic control systems. However, since he has been away from college three or four years, his mathematics will be a bit "rusty." Contrary to the average engineering senior who knows little about servomechanism components, he normally is familiar with a large number of control system components and knows a specific system in great detail. He is interested in gaining the necessary mathematics that will enable him to analyze the systems he expects to encounter in the forseeable future.

To refresh mathematical skills, it is necessary to devote a number of lectures to the review of differential equations and to develop the Laplace transformation as a tool for use in the analysis of control systems. Once this initial mathematical orientation period is over, the material covered follows essentially the same as that given in the first course outlined above, but devoid of some mathematical proofs.

Because a four-hour evening laboratory is a considerable inconvenience to most of these students, the laboratory work can be restricted to the demonstrations of a laboratory system operating under prescribed conditions and the simulation of this system on an analog computer under similar operating conditions. This restriction of laboratory time should not be considered too severe, since these individuals usually have ample opportunity to perform their own experiments on the job. It can be said that all the important concepts covered in the regular courses are covered in the evening course. Some of the details are varied, however, to meet the needs of the class.

In summary, it apparently is possible to provide an undergraduate student with all the basic system concepts in a one semester, four-credit-hour course. To do any major amount of system designing, however, it is desirable that he also have the two semesters of graduate courses.

REMINDER OF DEADLINES FOR ASEE AWARD NOMINATIONS

The Selection Committees concerned have asked that the final dates for submitting complete award nominations, with all supporting materials, be re-emphasized:

Curtis W. McGraw Award	March 1, 1957
Vincent Bendix Award	March 1, 1957
Lamme Award	February 1, 1957
George Westinghouse Award	March 1, 1957
James H. McGraw Award	March 2, 1957

HYDROLOGY IN THE SANITARY ENGINEERING CURRICULUM

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Presented at the Civil Engineering Conference of 64th Annual Meeting, on June 28, 1956, at Iowa State College, Ames, Iowa.

Hydrology is that branch of physical geography which encompasses the behavior of water in the atmosphere, on the earth's surface, and underground. It is a relatively new science which represents interests cutting across geology, agriculture, geography, physics, meteorology, and civil engineering.

The first significant textbooks on the subject of hydrology were published in 1917 and in 1919. The next important texts on the subject, and there were at least three, appeared in 1949. This 30-year period between textbooks, however, was filled with great numbers of significant publications in the periodical literature and represented the time when hydrology was developing into the science it is today.

There are obviously many applications of hydrology in civil engineering design and construction. Even though one does not call himself a hydrologist, if he is practicing the profession of civil engineering there are many places where he must utilize a basic understanding of hydrology.

As a matter of review we might list some of the important contributions made by the science of hydrology to the civil engineering field. Before the bridge is built, the area of the waterway must be determined, and the size of the culvert under the roadway must depend upon hydrologic data. The effectiveness of storm drainage is dependent upon a complex analysis of ground slope, area, imperviousness, geology, climate, and a host of other factors all bearing on the hydrology of the project. The development of water supplies by impounding reservoirs and dams involves a determination of maximum expected flow as well as safe yield during an extended drought.

Multiple purpose dams are designed, built, and operated to satisfy the solution of rather complex hydrological problems. Irrigation is dependent upon the science of hydrology in many ways. Study of the snowfall in mountainous areas that produce water for domestic supplies is another facet of this science. Flood control structures, flood routing, locks, canals, etc., are all dependent, in their adequacy, upon hydrological analyses. The amount, movement, and quality of ground water is dependent upon a thorough understanding of a very complex environment.

Slowly we are unravelling the hydrology of ground water, but it is a highly involved and complex science that continues to baffle our engineers and scientists. The atmosphere is the source of all the hydrologic waters; therefore hydrology embraces an understanding both of weather and climate. One of the newest stepchildren

of the field is the attempt to modify precipitation, by cloud seeding, in arid to semi-arid regions. What an interesting field.

It is obviously an extremely broadening subject and could certainly contribute measurably to the culture of the civil engineering student as well as to his technical ability to design engineering projects.

To understand better where hydrology fits into the civil or sanitary engineering curriculum, we should first note the civil engineering courses which are in some way associated with hydrology. These would include at least the following: hydraulics or fluid mechanics; domestic and industrial water supply; sewerage and industrial wastes; highway, airport, and construction drainage; soils and foundation engineering; bridges, dams, locks, and other water control structures; and flood control and water power engineering. Note that highways, soils, structures, hydraulics, and sanitary engineering are involved.

It is apparent that the position of the sanitary engineering courses within the civil engineering curriculum must be clarified before the position of hydrology in sanitary engineering can be defined. Obviously there are many different points of view on sanitary engineering curricula. Permit me to express the opinion that sanitary engineering will be stronger if it stays within the fold of civil engineering, especially at the undergraduate level, and that sanitary engineers should get behind the civil engineering curriculum and help make it stronger instead of splitting off as has been done only too frequently. It seems quite improbable that a strong undergraduate sanitary engineering curriculum can be developed. There is so much work that must be taken in chemistry, bacteriology, and related scientific fields that if the sanitary engineer is to be educated for the needs of modern professional sanitary engineering work he most certainly must plan on graduate level work.

Recent trends in curriculum encourage keeping the curriculum basic, broad, and unsplintered. It seems wise then, in an effort to achieve this goal, that undergraduate sanitary engineering, from a curriculum point of view, be only a slight variation from other facets of civil engineering. There are certain sanitary engineering subjects that are essential for all types of civil engineers, which courses might quite logically be taught before the last year in school; then during the senior year the student engineer, leaning toward the sanitary engineering field, should be advised to take those courses which will fit him best for professional sanitary engineering work. This approach makes him first a civil engineer, then a sanitary engineering specialist.

Hydrology requires, as prerequisites, at least one course in statistics beyond the calculus and one course in hydraulics or fluid mechanics. There might be some question as to whether hydraulics is a prerequisite to hydrology or vice versa. Both statistics and hydraulics, it is assumed, are required in most of today's curricula for civil engineers. With this very minimum of prerequisites it would seem that hydrology might be taught during the third year where it might lay the fundamental groundwork for the other courses that were previously mentioned as having hydrological implications. Under this arrangement all civil engineers would be required to take the course.

If we require third year civil and sanitary engineers to take the course in hydrology, it is obvious that real progress could be made in developing the basic principles behind hydrological methods utilized in other courses. Instead of simply approaching, for example, the hydrological aspects of a highway drainage problem from the handbook and empirical formula route, the student should have the background to understand why the problem is to be solved in a given manner involving inductive thinking.

Here we have an opportunity to contribute to the education of the student rather than simply training him how to use formulas from a handbook. The same reasoning applies to the courses of water supply and sewerage. If the basic principles of hydrology are covered in a required course in hydrology, the following associated courses could devote more time to specific applications or even devote the time now spent on hydrology in associated courses to other important matters.

In strict contrast to the proposal of requiring all civil engineers to take a basic course in hydrology is the more common approach to the subject, the generally accepted practice of offering the first hydrology course as an elective during the senior year. In view of the fact that only five per cent of the civil engineering graduates use hydrology to any great extent, as borne out by the ASCE hydrology committee report of 1950, this may be justified.

If hydrology is offered as a fourth year elective, then sanitary and hydraulic engineering majors should be stongly advised to take the course, while highway and structural engineers should find it extremely useful. It is obvious that such a broad field as hydrology cannot be adequately covered in one course. This suggests that the subject should be extended and offered as a graduate level course, providing a continuation of the introductory or undergraduate course.

A course in hydrology should be thought-provoking for the student and a real challenge to a capable, talented, and well informed instructor. Many of the basic courses in civil engineering are taught by deductive thinking methods, where the student progresses from general principles and laws to details and particulars. In hydrology lies the complete reverse of this philosophy, as the student gathers detail data and by statistical and hydrological methods evolves a general law. This process is inductive reasoning, as suggested by Professor Ray K. Linsley in a paper presented to this group at the last annual meeting. The student will find in hydrology that the answers are not cut and dried and that it is reasonable to arrive at an answer somewhat different from the results of his classmates. This course permits him to apply some of the statistical methods which were derived in his mathematics course in statistics. It permits him to develop underlying principles and to do some real thinking.

Now that we have examined the hydrology situation we can logically conclude that there are some real advantages in offering the course as a basic third year requirement for all civil engineers. This is the most logical and scientific approach. If the curriculum doesn't call for this treatment, then the sanitary engineer should be advised to elect the course in the fourth year and if possible extend his hydrology education as a graduate.

THE ROLE OF EVENING ENGINEERING EDUCATION IN THE TRAINING OF TECHNICIANS

S. B. INGRAM

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Presented at the ASEE Annual Meeting, Ames, Iowa
June 27, 1956.

What can evening education for technicians do to help solve the engineering manpower shortage? To begin with, there are three directions in which we, as a nation, can move to overcome the shortage. We can produce more engineers; we can produce better engineers; and we can make better use of those engineers we already have. Evening engineering education can make a substantial contribution to two of these.

In the first place, it can help to produce many more engineers because many technicians whose formal education terminated at the high school or two-year college level are capable of developing to the full professional level based on a four-year accredited engineering training, and the only way many of them can achieve this development is evening education.

In the second place, it can help to develop the abilities of technicians as technicians in their primary function of supporting the work of engineers. Further training in engineering subjects, even if it is not pursued to a degree, can enable many technicians to contribute on a higher level in their jobs. This will relieve engineers for work of a more professional grade. We need better technicians not just more of them, and there is a wide range of job responsibilities within the technician category.

There is, therefore, a real need for evening engineering education accessible to the technicians where they are employed in industry. I believe that it is part of our colleges' responsibility to the community to supply this need.

If evening engineering education is going to play its proper role in the production of engineers and the development of technicians, what is required of it? The first requirement is that it be widespread, because only those technicians who are employed in industry close to one of the centers offering an evening program can avail themselves of its advantages. The second is that it be of high quality so that the professional engineer who receives his degree by the route of evening education does not have an inferior training.

Quality of Evening Education

The quality of effort which the evening student puts into his scholastic work is usually of high grade. He has a maturity seldom found among day students. What he lacks in youth and freshness he makes up in determination and seriousness of purpose. He has a practical background of experi-

ence in industry into which to fit his academic work.

Motivation is an important factor in the learning process and the evening student is highly motivated. He believes he needs an education and he intends to get it. He would not be using his precious leisure time to study if he were not strongly motivated. He deserves a good education. It is the responsibility of our engineering colleges to give it to him.

It should be the objective to do away with the difference which personnel people in industry have been accustomed to draw between "day college graduates" and "night college graduates." The way to do it is to raise the standards of evening programs to the accredited level.

Accreditation

The recognized agency for accrediting engineering curricula in the United States is the Engineers' Council for Professional Development. Its policy is to maintain identical standards in the accrediting of day and evening curricula. In the 1955 ECPD list, 151 institutions are listed as being accredited in engineering.

Only nine of these have accredited evening programs. Of these nine, five are in the New York Metropolitan area. Others are in Pittsburgh, Cleveland, Detroit, and Washington. Two of these have received accreditation within the last year. Other metropolitan areas have evening programs which are large in their enrollments but which have not been developed to the level of accreditation. Examples are Chicago and Philadelphia.

In some of our large industrial centers, no degree programs, accredited or non-accredited, are available to the technician having the ability and the industry to develop himself to professional status—*i.e.*, Boston.

Importance to Industry

Our company had an experience which illustrates, I think, that industry is properly concerned with this problem. We opened a branch of our Laboratories in the Boston area and in the course of the move wished to transfer personnel, including a number of technical aides, to the new location. A recent survey shows that at our New York and New Jersey locations about 19% of our employees in the technical aide classifications are studying toward degrees at one of the several excellent schools offering accredited evening programs in that area. In the particular group to which I refer about 25% were doing so. These people were reluctant to move and we felt that although the transfer to the new location would be in the best interest of the company, it would result in an unwarranted hardship on the men because they would be unable to continue the educational program on which they had embarked.

The development of graduate evening programs in engineering, on campus and off campus, is proceeding with great vigor in response to an active demand from industry and its engineering employees. It has become a widely established practice in industry to give financial aid to its engineering employees in advancing their further educational development. The need exists also on the undergraduate level and industry again widely offers its encouragement and support. While much progress too has been made in this field, the availability of facilities is uneven and much remains to be done in the im-

TABLE I

ESTIMATED POTENTIAL EVENING ENGINEERING ENROLLMENTS

(1) Metropolitan Area	(2) Population 1950 Millions	Enrollment—1955 (3) Accredited	(4) Non-Accredited	(5) Total	(6) Enrollment per 100,000	(7) Estimated Potential Enrollment
New York	12.9	5,615	—	5,615	44	5,615
Chicago	5.5	—	4,028	4,028	76	2,400
Los Angeles	4.4	—	253	253	6	1,900
Philadelphia	3.7	—	413	413	13	1,600
Detroit	3.0	—	312	312	10	1,300
Boston	2.4	—	—	—	—	1,000
San Francisco-Oakland	2.2	—	—	—	—	1,000
Pittsburgh	2.2	561	531	1,092	50	1,000
St. Louis	1.7	—	3	3	0	750
Cleveland	1.5	867	—	867	59	650
Washington, D. C.	1.5	—	39	39	3	650
Baltimore	1.3	—	529	529	39	600
Minneapolis-St. Paul	1.1	—	—	—	—	500
Buffalo	1.1	—	—	—	—	500

provement of academic standards for both undergraduates and graduates.

Availability of Evening Education

Some rough, but nevertheless interesting, estimates of the size of the evening enrollments which might be developed in some of our large industrial centers if facilities were made available are set forth in Table I. The table gives the 14 metropolitan areas listed by the U. S. Bureau of the Census as having a population of over one million in 1950. The 1955 evening enrollments have been taken from the figures of the U. S. Office of Education (1), and divided between accredited and non-accredited components by the 1955 ECPD accreditation list. There are some obvious discrepancies in the figures, arising no doubt from the method of reporting the evening enrollments in certain institutions.

For example, two of the institutions shown as having accredited evening curricula in the ECPD list are not reported as having enrollments in the Office of Education figures. No attempt has been made to reconcile these discrepancies. In the metropolitan area consisting of New York and Northeastern New Jersey, where well-developed programs have existed for years, there are 44 enrollees per 100,000 population. Other centers such as Pittsburgh, Cleveland, and Chicago show that New York is not unique, though not all the programs in the other cities are accredited. Column 7 gives estimated figures for potential evening enrollments in the other areas assuming that the same ratio of enrollment to population would be realized elsewhere as it is in New York if equivalent facilities were available. The interesting comparison in this

table is between the figures of column 7 and those of columns 3 and 4. Many of the legitimate needs for evening education are obviously going unsatisfied because of lack of suitable facilities.

Need for a Survey

I should like to conclude by proposing that the two divisions which are sponsoring the conference this afternoon, the Relations with Industry Division and the Evening Engineering Education Division, carry out a survey in this field. Such a survey would be much more reliable and informative than the crude estimates which have been made above. Both industry and the colleges should participate. Industry could supply much information on the local needs and the colleges could provide information on the available facilities. The results of the survey would be useful to the institutions in planning their programs in this important area of their community responsibility.

Reference:

1. William A. Jaracz and Henry H. Armsby, "Engineering Enrollments and Degrees, 1955," JOURNAL, Vol. 46, p. 509, (Feb., 1956).

ROCHESTER EXPANDS PROGRAM

The University of Rochester, New York, will expand its Division of Engineering by adding a four-year undergraduate program in electrical engineering beginning in September, 1957. Students also will have the option of a five-year course in which they may obtain both a bachelor of science degree in electrical engineering and a bachelor of arts degree with a major in a liberal arts field. In the fall of 1956, the Graduate School began a master's degree program in electrical engineering under which practicing engineers may study for their advanced degree in evening classes.

EVENING ENGINEERING EDUCATION AND ITS CONTRIBUTIONS

CHARLES E. SCHAFFNER

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A paper presented to the joint meeting of Evening Engineering Education and Relations with Industry Divisions, Iowa State College, Ames, June 27, 1956.

Describing the contributions of Evening Engineering Education is at once an easy and a difficult chore: easy, because of the many and significant contributions made through the years; difficult, because of the rapidly changing patterns developing as colleges and industry join in experiments designed to solve individual problems. Many of the contributions are of a general nature and apply throughout the country. Others are more specifically applicable to particular situations or particular colleges.

Rather than discuss these contributions on a broad scale, I shall try to outline them as they affect the three interested participants: the college, the student, and industry. And throughout the discussion, I shall use our experiences at the Polytechnic for illustration; first of all because I am most familiar with our conditions and our problems and secondly because the Polytechnic Institute of Brooklyn has been one of the founders and largest practitioners of part-time education.

The College

The Polytechnic started evening engineering undergraduate degree programs in 1904, more than 50 years ago, and evening graduate degree programs more than 25 years ago. Today Poly has 1801 evening students studying in engineering undergraduate degree programs – the largest ECPD-accredited program in the country – and 97 non-matriculated students. In addition, there are 1165 evening students studying in engineering graduate degree programs plus 121 unclassified students. This is also the largest number in the country, representing 45% more than the next largest school.

Supplementing the engineering enrollments are 102 undergraduates in science, making 2000 and 482 graduate students in Science for a total of 1768. These figures compare with a full-time undergraduate enrollment of 1539 engineers and 143 scientists totaling 1682 and a full-time graduate program of 66 engineers and 110 scientists for a total of 176. Since the part-time students average approximately 1/3 to 1/2 of a full-time program, it can be seen that the Evening program is almost as large as the Day program from the standpoint of contact hours.

The undergraduate evening curriculum is exactly the same as that offered to full-time students. There is no fixed schedule of offerings term

by term. Each student is free to plan a program which will fit in with his other commitments. This combination of individual programs and one curriculum for Day and Evening students produces the flexibility which is needed to cope with changing work and home conditions.

A schedule such as this results in very effective use of facilities. The day begins at 9 a.m. and doesn't end until 10 or 11 p.m.; during all this time many of the seats never cool off. The average classroom is used approximately 11 hours each day. The net effect of all this of course is to provide the lowest possible tuition cost to the student. The combined Day and Evening program results in a lower cost than either would pay if forced to stand alone. While keeping costs down, operation of a sizable Evening Session still permits the retention of a larger full-time staff than ordinarily would be possible, with all of the attendant advantages which this brings.

At the Polytechnic, each staff member is expected to carry about one-third of his load in the evening, which would result in about one-half of the evening contact hours being handled by full-time personnel. The remaining half provides two very useful purposes. First of all, it serves as a cushion to preserve the size of the full-time staff regardless of variations in full-time enrollment. Any reduction in full-time enrollment can be absorbed by increasing the evening load for each man. Thus the one-third load mentioned above is an ideal situation which will increase as full-time enrollment decreases and decrease as full-time enrollment increases, particularly in times of teaching applicant scarcity.

The second purpose served is that of the opportunity afforded the institution of bringing in many highly qualified men from industry and consulting practice. These men provide the school and students with a reservoir of talent and knowledge which otherwise could not be tapped. In so doing, they also serve as highly effective liaison between the college and the profession, to the advantage of both.

The final advantage to the college which I would like to cite is that of reduced attrition. All of us are familiar with the awful toll that takes place along the path from the freshman year to graduation. Some of this is unavoidable regardless of admission practices, counselling, or any of the other devices we employ. There is not much that can be done in time to help the immature students, the one who lacks real motivation, or the man whose family needs his earning capacity.

Considering the uniformly rigid academic entrance requirements, these are the men who make up a heavy percentage of the normal losses of the average engineering school. There is one thing which can cure all three of these conditions faster than any other single factor—a job in a related field. Thus the school with an Evening Session is in a position to help the intellectually able full-time student who is having trouble; in many cases such a program will succeed in salvaging a man who normally would have become a casualty.

As an illustration of this, during the past three years the number of undergraduate degrees awarded by the Polytechnic has ranged from 385 to 512 for an average of 450. Of this number, an average of only 56 or

12% represented men who started at Poly in the Evening Session and went through the entire curriculum as evening students. An additional 79, or 18%, were students who transferred into the Evening Session from other institutions so that a total of 30% of the degrees were conferred on men who had never attended Polytechnic as full-time students.

Another 77, or 17%, however, spent some time as full-time students and some as part-time students. This number, plus a substantial percentage of the 79 who transferred into the Evening Session from other institutions, represent men who might well have become fatality statistics without the Evening Session. It would appear conservative to conclude that an average of 15% of the degrees cover former full-time students who never would have graduated otherwise.

When these three categories are added together, we find that 47% of the graduates have spent all or part of their stay at Poly as part-time students. Incidentally, I use that term—"part-time students" deliberately since the distinction at Poly is really between full-time and part-time more than between Day and Evening. This figure does not include Day Session students who register for one or two Evening Session courses because of program difficulties. Nor does it include Day Session students who work full-time during the summer and attend courses in the Evening Session. Only if these numbers were added to the 47% already quoted, would one have the true measure of the contribution of the Evening Session.

The Student

Large as the contribution is to the Institution, the Evening Session contributions to the students are even more significant. The most obvious is that it affords an opportunity for higher education to the man who could not or would not attend college after graduation from high school. This includes those who were not motivated until employment had demonstrated the advantages of further education, as well as those who could not afford to attend college on a full-time basis.

It is for these latter men that evening study expresses itself as an outstanding factor in the American tradition of free opportunity regardless of origin and wealth, an opportunity which is also offered to full-time students who are forced to leave college for financial reasons. For Poly's continuing full-time students, the Evening Session provides answers to otherwise unsolvable conflict problems, often saving men at least a term if not an entire academic year. It is also of substantial help to the full-time man in financial trouble, permitting him to free a full day for work; or, if there are courses he must make up in the summer, it enables him to work full-time while doing so.

In addition to all of these advantages, evening study provides the student with one of the most effective forms of cooperative education. The day by day work experience supplements and strengthens the student's academic training and of course his studies are of inestimable value in his job progress. In this respect, it is interesting to note that at least 95% of the evening students at the Polytechnic are working and studying in the same field. This is true almost from the entering class on, since approximately 85% of the entering students are so employed.

Although evening study normally is not considered when the term "co-operative education" is used, it is obvious that it has most of the advantages usually attributed to the latter. In fact, taking advantage of the summer session and the fact that the Day and Evening curricula at Poly are identical, a man could complete his degree requirements in four years, meanwhile accumulating thirty months of full-time work experience. This would be accomplished by transferring back and forth, spending two of every three academic semesters in the Evening Session and the third in the Day Session.

While this would appear to be a demanding schedule, there are a few men graduating this year who entered Polytechnic in February, 1953. The fact that they received their degrees in 3½ years is not unusual since we have a February group which does this every year. Along the way, however, these men spent five full terms in the Evening Session, with a total of twenty months full-time work experience. Here, then, are men who have completed a normal engineering program in a normal period of time, but who certainly have far more to offer an employer than the usual graduate can.

Industry and the Profession

So we come to the contributions of evening study to industry and the profession. The first and most obvious of course is that of increased training which automatically means increased usefulness. Industry has placed an ever-accelerating emphasis on training programs during recent years. On an employee-voluntary basis, Evening study is of course the least expensive training possible, since the program costs the company nothing. Even when the company pays the full tuition, however, the cost per man per hour of his class time is usually less than his salary per hour. In addition, the employee does all of this on his own time, thus freeing his entire work day for useful production.

That industry appreciates the importance of such programs is demonstrated by the results of a recent survey of our part-time undergraduate and graduate students. Represented are 1122 companies, of which 162 companies pay all or part of their employees' tuition. These companies employ 1266 students or 33% of the total. When one considers that 151 are special students from other colleges, are self-employed, or were between jobs when the survey was taken, the percentage of employed students whose tuition was paid becomes even larger.

The corresponding figures for last year were 92 companies employing 932 students, which means that this year's increase was 76% in companies and 36% in students. One does not have to be a seer to predict that within a relatively short period a great majority of students will receive some form of company help. An examination of newspaper advertisements gives rapid proof of the important part this approach plays in recruiting.

Tuition Payments

These tuition payment plans vary widely in scope and character, from a minimum of one-half tuition with a yearly $100 maximum payment to all tuition and expenses paid, with over-time rates for each hour in the classroom. Some firms make payment upon registration, while others withhold payment until after completion

of the courses. In addition, there are some plans where the company varies the amount of payment depending upon the grade received.

I might say that, in our opinion, the most satisfactory plan is one in which the student pays the entire tuition at registration and upon satisfactory completion receives partial or full reimbursement, according to company policy, regardless of grades. In general, we feel that for the sake of proper motivation it is important to have the student participating financially, at least for the duration of the course.

In addition, we feel there is already sufficient pressure on student and instructor with reference to grading, without adding a financial one as well. One interesting variation on this plan is that used by one company which pays one-half the tuition upon completion of the course and the remainder upon completion of the Master's degree requirements. This of course is more practical in graduate work than undergraduate, since the requirements for the Master's degree can be completed in two to three years while those for the Bachelor's degree usually take six to ten years.

An interesting result of these tuition payment plans is that the institution finds itself in the position of subsidizing the company training program. You are all familiar of course with the fact that most privately supported colleges charge a tuition rate which covers only one-half to three-quarters of their costs. The remainder is made up by income from endowments and by gifts. Thus, if we assume the larger figure of three-quarters, Polytechnic is in effect subsidizing each of 162 companies in varying amounts ranging up to as much as $40,000 per year for one company.

This is a situation which is gradually being recognized by both industry and foundations as evidenced by recent scholarship awards which include flat grants to the institution equivalent to the tuition grant to the student. Perhaps in the near future industry may find it possible to make the same arrangements in their tuition payment plans for evening students. This would be a salutary development; it would help institutions to broaden their offerings, increase their services, and perhaps even bring instructors' salary levels back to their relative position before World War I.

There is one very important contribution that an increased amount of accredited evening study could make to industry that has been given little thought until recently. With the constant growth in the economy, the increasing diversity of production, and the dependence upon research, it has become imperative for many companies to open additional plants, laboratories or consulting offices in new locations throughout the country. In selecting a site for a new establishment, there are many factors to be considered which are too numerous to mention here. Perhaps the most important of these, however, is a source of manpower – particularly trained manpower.

In many instances, companies are finding it difficult to attract people, either new employees or their own trained personnel, to new sites if facilities are not available for part-time graduate study and part-time accredited undergraduate study. The technician who has studied in the evening for five or six years, because his company has told him he cannot

progress without a degree, will not readily move to an isolated area where he must give up all chance of completing his degree program.

Just how serious a situation this is cannot be understood until one examines the ECPD-accredited list of undergraduate engineering curricula. Until this year there were only seven of the 151 accredited institutions in the country which had accredited degree programs in the evening. Even more amazing is the fact that five of these schools are located within the metropolitan area of New York City. The other two population centers represented were Pittsburgh and Cleveland. This year, two more areas have joined the list, Detroit and Washington, D. C.

Thus at the present time, only five of the large population centers in the country have at least one accredited evening program to offer industry and the public. A more dramatic way of illustrating the sparse distribution of evening programs in the country is to point out that the Polytechnic has more evening undergraduate engineering students enrolled than the total of any state with the exception of New York, Illinois, Pennsylvania, and Ohio. Actually, 10% of the accredited engineering colleges of the country enroll almost 90% of the evening students.

Are Facilities Adequate?

Another measure of the inadequacy of present facilities is found in the numbers of students presently enrolled in evening programs. Many people have the impression that there are at least as many students studying in the evening as there are full-time students. Nothing could be further from the truth. As of October, 1955, there were 221,448 engineering students in the U. S., of which 190,355 (86%) were enrolled in ECPD accredited schools. Of these totals, 22,350 were studying in the evening, 19,136 (also 86%) of whom were enrolled in ECPD accredited schools.

In each case, the evening figure is only 10% of the total. Of these evening students only 7,043 (32% of the total) were enrolled in the 7 ECPD accredited evening degree programs. (The two schools just added to the ECPD list have not been included, since their enrollments were not reported to either A.S.E.E. or the U. S. Dept. of Health, Education and Welfare.) Thus, of all the evening students of engineering in the country, only 3% are enrolled in accredited degree programs. As an illustration of what can be done, one has only to examine graduate enrollments, where 44% of the totals for the country are evening students.

Under these conditions, what is the present contribution of evening programs to the elimination of the Engineer shortage—and what could it be? The exact contribution in numbers produced is a difficult thing to evaluate. As was pointed out earlier, the number who complete the entire evening program represent only a small measure of the complete contribution. This is also true if the number of evening graduates each year were used, since many evening men transfer to the Day Session. In addition, these figures are not readily available.

If an attempt were made to compare numbers of graduates on the basis of full-time enrollment varying admissions practices and different academic standards would be involved. If the freshman class were used as a base, varying admissions

practices would again be involved. The scheme finally adopted is one in which the number of graduates for a given June is divided by the number of full-time seniors of the preceding September. The senior class was chosen to eliminate as far as possible the variations just mentioned. In addition, in these times of heavy enrollments it provides a good index of relative capacity or size of school.

Obviously, the result of such a division will be a number less than one for schools with no evening sessions, since not all of the seniors in any given year will graduate. Just as obviously, the factor will be greater than one for schools with evening sessions. The interesting thing is to see how much the factors vary and what is their significance in terms of numbers of engineers produced.

In these computations, 6 of the 7 schools with accredited evening programs have been used (Carnegie Institute of Technology, Cooper Union, Fenn College, New York University, Newark College of Engineering, and Polytechnic Institute of Brooklyn). City College of New York has been omitted because their statistics are reported differently than the other institutions.

The figures have been computed for the last five years and show that for this period the factor for the country as a whole is 0.94 (not including the six colleges mentioned) or in other words for every 100 seniors in September there are 94 graduates in June. For the six colleges indicated above, the factor is 1.24. If this factor had prevailed for the whole country, the past five years would have seen 45,000 more engineers graduated or 9,000 per year which would have shown an increase of approximately 30% over the 30,-900 per year average figure.

Of course the factor varies considerably even at these six institutions —not only among the institutions but also by years at an individual school. There are many factors which affect the ratio, one of the most important of these being the ratio of part-time students to full-time students. For example, the factor varies from a low figure of 1.00 for one year at Cooper Union to a high figure of 1.74.

For the five year average, the variation is from 1.07 for Carnegie Tech to 1.52 for Cooper Union. In terms of numbers, the significance for one institution is as follows. The Polytechnic, whose factors ran from 1.11 to 1.64, averaged 1.32. If the low factor of 0.94 applied to Poly, she would have granted only 1,555 degrees compared to 2,190, or 311 per year compared to 438, a decrease of 127 per year.

It is, of course, obvious that the figure of 9,000 is an artificial one. It is impossible for a campus college, with no neighboring metropolitan area or adjacent industrial plants, to maintain an evening program. However, there is certainly much that can be done in schools which are in population areas of sufficient size to carry an evening program. Perhaps half of the 151 accredited institutions in the country are in locations which would permit them to carry on an evening program on a substantial scale.

Total Contributions

These then are the contributions of Evening Engineering education: to the college—a more effective use of facilities, a larger, more stable staff, the use of professional practitioners on a part-time basis, and less attrition; to the student—an opportunity

to learn while he earns, flexibility of schedules, and the advantages of co-operative education; to industry—increased training at minimum cost and no loss of production, easier recruiting both in established plants and in new locations and greater numbers of graduates.

I have deliberately not mentioned the contributions to the community and the nation because, like Mr. Wilson, I believe that what is good for the college, the student, and industry, is good for the nation. However, I might point out that in the light of the afore-mentioned advantages of an evening program, it is readily apparent that a community which can offer it is in a good position to attract new industry, all other things being equal.

The contributions of evening programs in these past 50 years have been enormous, but they will be dwarfed by those of the next 50 years if industry and the colleges recognize their responsibilities and work together to create ever new opportunities for the evening students of the future.

NOTE: All of the statistics quoted, with the exception of some specifically applying to the Polytechnic, were drawn from the following sources:

Engineering Enrollments and Degrees 1954, 1955 U. S. Dept. of Health, Education and Welfare

Journal of Engineering Education—Yearbook 1949-1950—American Society for Engineering Education

Annual Report (Twenty-Second and Twenty-Third) Engineers Council for Professional Development

CONGRATULATIONS TO THE JOURNAL OF ENGINEERING DRAWING

The *Journal of Engineering Drawing*, published by the Division of Engineering Drawing and Descriptive Geometry of the ASEE, commemorated its 20th anniversary with its November, 1956, issue. The issue paid special tribute to the first Publication Committee which was made up of Professor Frederic G. Higbee, Professor John M. Russ, and Dr. Clair V. Mann, all of whom contributed to the anniversary issue. Professor Irwin Wladaver, editor of the *Journal of Engineering Drawing*, and his staff are to be congratulated upon the "New Look" of their *Journal*. Long may it contribute to all those interested in engineering graphics.

THE ENGINEERING TECHNICIAN: HIS ROLE IN INDUSTRY AND NATIONAL DEFENSE

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The technician, a relative newcomer to the industrial field, has become increasingly important to both the engineering and manufacturing activities of American industry.

Without the technician, industry is robbed of much of the potential effectiveness of its engineers—for these engineers are forced to devote a large percentage of their time to layout and detail type drafting, laboratory test work, fabricating models, working with building blocks, and other non-challenging and non-creative activities. With an abundance of competent technicians on hand to assume the bulk of these and many other responsibilities, the engineer is freed to devote his time to the creative type work he has been trained and employed to do.

Unfortunately, although much more publicity has been given to the shortage of engineers, we also have an acute shortage of technicians. By relieving this shortage, and as a result enabling our engineers to devote more time to their proper creative work, we also will be helping to alleviate the shortage of graduate professional engineers. In effect, we will be killing two birds with one stone.

To give some idea of the number of technicians we need, let me cite some figures from my own company, which I believe is more or less typical. At present we have approximately 120 graduate engineers. We also have about 160 trained technicians, not nearly enough. We probably should have a ratio of at least three technicians to each engineer. Any ratio below this simply means that we are not getting maximum productivity from our staff.

Technician's Duties

The specific duties which would be assigned to a technician in industry would of course vary somewhat according to the nature of the work being conducted by his company. The following functional job descriptions have, however, been found suitable to the technician's training, background, and maturity.

Design Engineering—Test work as assistants to experienced engineers, fabrication and assembly of experimental and development models from minimum information, drafting and design under the guidance of skilled designers, and some technical writing.

Production Engineering — Preparation of methods analyses, design of production tooling, and participation in production control functions, again under the direction of persons skilled in these areas.

Production Operations—Functional inspection in sub-assembly and final test operations, lead men and technical assistants to foremen in plating, silkscreening, and other technically complex fabrication functions, and in the installation, maintenance, and

modification of plant equipment or facilities. This function will undoubtedly become more important as we become more mechanized.

Accounting, Sales, and Service—The technician is becoming increasingly useful in cost estimating, particularly when this function involves the interpretation of technical information, sales engineering, sales forecasting, sales analysis, and field service operations to support the utilization of complex technical equpment by the customer.

It almost goes without saying, however, that these job classifications do not necessarily represent ultimate career positions for the technician. They might better be described as starting positions which most industries have available immediately, and which most formally trained technicians could fill.

When the technician goes from any of these starting points is largely up to him, but the company also shares some responsibility in advancement. The company should provide a working and training environment which encourages the technician to expand his skills, his knowledge, and his usefulness. Moreover, whenever a technician adds appreciably to his formal education or his job—acquired know-how, the company should increase his responsibilities accordingly.

The point I am trying to stress here is simply this: No company should take the stand that "once a technician, always a technician." Many individuals who originally were hired as technicians have become qualified engineers. These are people who, by virtue of their work experience and continued formal education—with aid from the employing company, are now qualified to hold down jobs which call for graduate engineers.

It is as important to the company as it is to the individual that the doors for advancement and opportunity remain open for all employees. The technician is no exception. If we expect him to be a useful member of our team, we must provide satisfactory lifetime goals for him, and then help him attain them.

Also, encouraging our technicians to further their education, we certainly can not require that they stick to technical fields. We are not only interested in increasing the individual's technical competency but also in broadening his educational base. It is very desirable that engineering technicians expand their interests into each areas as economics, law, cost accounting, sales, and general education.

In order to further this type of progress among our employees at Link, we have adopted the policy of supporting one-half the tuition costs for those who elect to take such courses. In many cases, in addition to paying half the tuition, the company has granted leaves of absence to individuals so that they could attend colleges or universities on a full-time basis.

You might ask why we do not pay all the tuition costs. The primary reason is simply that we want to make sure our employees really want to further their education and are not doing it just because it is free. If they are willing to pay half the cost, then we know they are serious about wanting to study. By paying the other half, we are making it easy for them—but not too easy.

Among technicians as well as any other group, individual capacities will

vary. Some will be content to remain in minor technical roles, while others will strive to become top-notch development engineers, supervisors, or members of top management.

It is our philosophy that the ground should be prepared and a fertile growing climate provided by the company – but the initiative should originate with the individual. Thus those who really have the capacity and desire to climb the ladder are given an opportunity to do so, but an automatic, painless filter is provided for the individual who chooses not to progress.

We in America are not the only people who recognize the growing importance of the technician to industry. One of the reasons Russia is outproducing us at present is that she puts great emphasis on the training of technicians. The Russians have a broad and extensive secondary semi-professional training program which consists of more than 3,500 separate schools (or Technicums) with an average enrollment in the vicinity of 400 students each. This means that there are well over a million students between the ages of 14 and 20 receiving formal specialized vocational training in Russia today.

Of course, all of these students are not enrolled in engineering schools, but in view of the current Soviet emphasis on such training, more than likely a large percentage of them are preparing for specialized careers in engineering and manufacturing. Moreover, the majority of these engineering institution offer full four-year courses.

We do have vocational high schools, junior colleges, two-year technical institutes and extension programs whereby this type of training is given —but these programs are not very extensive in America. For example, there are less than 500 junior colleges in the United States, and the majority of these are liberal arts or business schools.

Perhaps one of our largest sources of skilled technicians and semi-professionals is American industry itself, which offers many types of cooperative and on-the-job training programs. But, when we are comparing our training facilities with the Russians, we must not forget that the Russians also have extension courses and on-the-job training programs which supplement their secondary semi-professional school system.

There are many things we can do that will bear results in a minimum of time. While we are taking this emergency action, we also should be laying the groundwork for a long range program which will insure that such shortages of trained man-power will never reoccur.

One thing that industry can—and is —doing to minimize the man-power shortage is to improve its utilization of engineers and technicians. By devoting more time to "fitting the man to the job", eliminating wasted or duplicated effort, giving the routine paperwork to someone else, giving engineers opportunities for advancement that do not require a switching over to the managerial or supervisory fields, fostering job satisfaction—by doing all of these things and many more, industry is doing its best to insure full and effective use of its engineers and technicians.

In the realm of formal education, there are perhaps several "emergency" measures we can take. I think that one

of the best possibilities would be a revival of something like the World War II ASTP (Army Specialized Training Program). I have talked about this idea to various people in the past and am almost invariably told that the cost would prohibit its effectiveness.

My only answer is that no cost can be too high when the stakes are even higher. If we cannot "afford" to educate our people in the direct interests of national security, then we cannot afford to maintain an Army or an Air Force, we cannot afford to spend billions in foreign aid, we cannot, in fact, even afford the privilege of being free Americans.

In 1956 we will graduate in the vicinity of 23,000 engineers. At a cost to the government of about $25 million a year, I believe in four years we could be graduating at least twice that many.

If we took 25,000 youngsters, who otherwise would be financially unable to go to college, and offered them a $1,000 annual scholarship with the stipulation that they in turn fulfill certain military obligations, then I think that $25 million a year outlay would be one of the wisest we could ever make.

Such a program operated on a government level—plus a parallel industry-sponsored program featuring outright scholarships, company training programs, and cooperative educational activities with the schools—would go a long way toward relieving the situation in a minimum of time.

I believe we would have little trouble recruiting 25,000 young men for this program from those who would like to go to an engineering college but who cannot afford an education. They might not be the so-called "cream of the crop", but they would be qualified and deserving high school graduates.

Though we may have many would-be engineers and technicians on the "waiting list" today, I think the problem of "where will they come from" will be much more acute in the years to come. And I believe that the cause for this can be traced right back to our secondary schools.

Our secondary schools today are failing to give our youngsters the science and math training they need in order to acquire a firm foundation for an engineering career. The school system requires so-many-years of English, foreign language, and history, but where are the so-many-years of physics, chemistry, advanced algebra, and other forms of higher math?

Many of our educators will reply that only a relatively small percentage of our secondary school youngsters have the aptitudes and abilities to be successful in such scientific and mathematical courses, and that is why these subjects are not generally required.

Although I agree that not *everyone* can become a good engineer or a good technician, I think there is a large number of youngsters in our secondary schools who could, *but do not even know it*. That is why I think we should put much greater emphasis on the study of math and the sciences in our secondary schools. I think students should be required to take such courses as physics, chemistry, and higher math, even if they do not think they can do the work.

By offering our secondary school students a wide range of elective courses, we are inviting them to choose the ones which appear easiest, and to

follow the path of least intellectual resistance.

If these youngsters were a few years older and more mature, perhaps they would not make that mistake. But at their age, they are more apt to be interested in "snap courses" and a minimum of homework than they are in careers.

Just for comparison, take a look at what the Russians are doing in their secondary schools. The Russian 10-year school, which is equivalent to our 12-year program, has for many years required that its students devote an average of about 40% of the total school hours to studying the sciences.

Moreover, the Soviets announced that as of the fall of 1955, "more time would be devoted to teaching physics, chemistry, and biology, reducing the study of humanities to secondary importance". Humanities and social sciences now constitute only about 47% of the entire Russian secondary school program.

The Russian emphasis on science and technology contrasts sharply with the situation in the United States. Whereas each of the more than one million Russian students graduated from secondary schools last June had taken 5 years of physics, 1 year of astronomy, 4 years of chemistry, 5 years of biology, and 10 years of mathematics, less than a third of approximately the same number of American high school graduates had taken as much as one year of chemistry. About a fourth had taken a year of physics, and less than a seventh had taken any advanced math.

By advocating that we require our secondary school students to take more math and science subjects, I am not at the same time advocating that we *require* them to become engineers and technicians.

However, we would be accomplishing several good things. First, we would be insuring that all students at least give such subjects a fair trial. By thoroughly indoctrinating these students in science and math, I am sure that we would be fostering a wider interest in those fields. Moreover, such students would learn to perform useful household technical chores which now, as adults, they are unable to do.

Secondly, the added science and math courses given at the secondary school level would provide a solid educational foundation for those students who decide to stay in the field. These courses would give them an improved background for the advanced studies they would have at the college level.

One need if we are to improve our secondary schools, is an adequate supply of good high school teachers. There is little point in my reviewing the acute shortage of teachers—especially of science and math teachers—and the primarily financial reasons for this shortage. I am sure you are all aware of the basic facts. The important point is this: *Without more good teachers, our school system cannot even do a good job with its present limited scientific curriculum, let alone tackle an expanded program.*

One of the obvious solutions, of course, is to offer teachers more money and I am certainly in favor of this. But we all know that in spite of some slight increases which are being made today in teachers' pay—it will be a long time, if ever, before the teacher's pay in cash will be competitive with salaries in industry.

The more obvious remedies would be to offer our teachers better facilities, better surroundings, and better working conditions. This would cost money, but it would help make the teaching field more attractive.

There are other measures—more expedient and temporary in nature—which can be taken to help relieve this critical teacher shortage.

In an address given before the National Security Industrial Association, David Sarnoff suggested one plan which I believe has merit. Mr. Sarnoff proposed the establishment of a "National Educational Reserve" composed of qualified teachers in math, physics, chemistry, engineering and other related subjects, to be drawn from the technological ranks of industry.

He had in mind the release from industry, with full pay for at least a year, a reasonable number of men and women for teaching assignments in their local schools. Also included in this educational reserve program would be qualified people in industry who have reached the retirement age, and those willing to volunteer their services to teach in night schools without giving up their industry jobs.

Although the number of teachers recruited from any single organization would be small, the total number in the Corps would be large enough to have a tremendous over-all effect on the teaching of the sciences in our school system. Because of their practical experience, teachers in the Educational Reserve Corps would bring reality and vitality into their classrooms, perhaps stirring greater interest and enthusiasm in the minds of their students.

Mr. Sarnoff suggested—and I agree—that to make this program attractive, teachers in the Reserve Corps should be given recognition through membership in an organization similar to the various military reserves. To be effective, the program should be set up on a national basis and created by an act of Congress.

I think that still another measure can be taken to alleviate this shortage of teachers. It is the same thing we are doing in industry to minimize our engineering shortage, and that is simply to get more effective utilization out of our present supply.

One way of doing this would be to increase the length of the average school day to at least six academic hours. That would still be shorter than the average Russian or European school day, but it would provide time for more classes.

Another way of getting better utilization is to get better teachers. By improving the caliber of instruction, adopting new and progressive teaching methods, and using up-to-date texts, we cannot help but turn out better qualified students.

All the topics I have discussed are vitally related. We cannot consider our technological race with Russia without also giving some thought to our shortage of technically trained people. And we cannot discuss this shortage without also discussing the educational system which produces our engineers and technicians.

In covering these various fields, I have made a few observations and criticisms and suggested a few programs which, if adopted, might help to turn out the engineers and technicians that American industry needs in order to compete with Russian industry today.

We should do whatever we can, whenever we can, to make our young people aware of the wonderful opportunities awaiting them in a technological or scientific career.

Our secondary school guidance counsellor system is inadequate and the counsellors seldom, if ever, have the experience and breadth of vision to fulfill their jobs efficiently. For instance, industry today demands technically trained men more and more for its top executive positions even though these men never practiced engineering as such, or at most for only a few years.

And by "wonderful opportunities", I don't just mean financial rewards either. I also refer to less tangible rewards such as the personal pride, the satisfaction, and the prestige that come from serving society through creative activities.

In addition to any financial or other material inducements we may offer our young people, we also should give them all of the moral support and encouragement that we can muster.

At the risk of sounding redundant, I want to re-emphasize how desperately America needs every good technically trained person she can get.

Adequate counselling in high school, greater emphasis on scientific subjects in the secondary school curriculum, more high-grade teachers, and aid for the gifted but finanically weak student would be big steps forward in filling the constantly growing needs for competent personnel.

PRATT'S NEW CURRICULUM

The Engineering School of Pratt Institute, Brooklyn, has announced a new common two-year curriculum for electrical, mechanical, industrial, and chemical engineering. Emphasis will be on mathematics and science without specialization, except for a minor amount in the junior and senior years. Students, who usually are unequipped to decide their field of specialization in the first year of college, will not have to make up their minds for two years. Eventually all basic engineering science courses will be taught in one department.

CHARACTERISTICS OF THE TECHNICIAN AS AN ENGINEERING AIDE

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Address at Technical Institute Division Luncheon, Ames, Iowa, June 27, 1956.

If I were to define an engineering aide as one who aided an engineer to do his work, you'd think I was being facetious. The statement is of course too broad, but it can serve as a starting point to characterize the engineering aide. Accordingly, I'll try to outline some types of engineering aides and what some of their desirable characteristics might be.

An engineering aide is a special type of engineering technician. The engineering technician covers a wide scope of skills ranging from the craftsman who works with drawings to the person who acts in the name of the engineer on selected engineering matters. First, let's examine these two extremes.

The Craftsman

The tradesman or craftsman engages in manipulative skills, and he may require long years of training and practice to be an effective and resourceful worker. His primary concern is how to translate a drawing into a model. In general he will not question the reasons for a particular arrangement shown on the drawing. He is interested in building it. To do this, he may exhibit considerable ingenuity, but any creative work he does is related to the manipulative process, and not to the final form of the device.

His concern is *how* to build the device, and a good model maker will build it in less time or with better quality or both than a less experienced man would. He will be able to build jigs or fixtures to speed the construction process, or to make it just within the required tolerances, and thereby not waste time on it in overbuilding it.

Now one may not find extreme cases such as these, where the model-makers are isolated from the engineer and work only from engineer's drawings. In fact, many model makers may inquire of the engineer why the model couldn't be built a little differently to make the construction job easier or cheaper. Many times these are good suggestions, and it is desirable for the engineer or engineering aide to work closely with the model maker so that advantage can be taken of his experience. I was thankful for the model maker who called me on one of my early design jobs and asked me how he was to build a washer with a larger inside than outside diameter! While the mistake was a purely mechanical one, it was nevertheless a mistake and could easily have happened where the error was not so obvious. An engineering aide or draftsman trained in such details could easily correct such errors, and I was glad that the model

maker found mine and took the role of the engineering technician in this instance. To summarize, the craftsman-technician primarily engages in manipulative skills in making a part or a device from a finished drawing, and while he may have considerable freedom in the construction process, he is not concerned with the final form the device takes. Therefore, he need not necessarily have contact with the engineer during the course of construction.

The True Engineering Aide

The man at the other extreme works very closely with the engineer. He may use little or no manipulative skill in his job. Rather, he may do actual design work, especially that which could be termed routine. An example might be the design of a circuit or of an amplifier which, while quite straight-forward, requires the application of physical principles normally obtained at lower college levels or from equivalent experience. He may act for the engineer in making routine design changes within the limits of the responsibility previously determined by the engineer.

Another example is the technician assigned as an engineering aide to a design engineer. The design engineer has completed and given to the aide a design for a gear train. A skilled aide could take the design, and on his own go completely through it, checking dimensions and angles by logarithms and verifying tolerances. A less skilled technician could do the checking, but the engineer would have to lay out the procedure for him and show him sample calculations. A highly skilled aide could design the gear train himself, given the overall objectives by the engineer. Thus, the closeness or understanding of the aide for engineering work determines his degree of importance to the engineer in releasing the engineer for more creative work requiring his professional training.

I believe this particular assignment to be an especially attractive one for a technician because of the opportunities which can exist for those who continue to learn and develop themselves technically. I dislike the use of the word routine in describing parts of this work, for this may lead one to believe that there is no challenge in the work, and I do not believe that this is true. From one viewpoint it may be routine in that some design work might be repetitive once principles have been established, but I find it difficult to imagine that there are many jobs which can be called routine in the sense that there is no challenge in them.

Differences

At this point, I would like to submit that the latter man I have been talking about is a true engineering aide, whereas the craftsman I spoke of earlier is not. The distinguishing feature perhaps can be said to be the personal contact, or the degree to which the engineer relies on the technician to do portions of his work. The craftsman does none of the engineer's work, though he aids the engineer in the total engineering *team* effort; indeed, he is an invaluable part of the engineering team. The engineering aide, as an engineering technician, is also part of the engineering team, and contributes to the team effort.

In addition, he may spend part or all of his time working directly for the engineer and will do work which the engineer would have to do if no

aide were available. Thus, if I modify my opening definition to reflect this point, it isn't quite as insipid: an engineering aide is an engineering technician with special skill or training which enables him to do selected parts of the engineer's job.

The engineering aide may have the engineer turn over a great deal of his work to him. In fact, the top technician or engineering aide at the Bell Telephone Laboratories, the Senior Technical Associate, carries sufficient responsibility and freedom for exercise of independent judgment to qualify him for exemption under the Fair Labor Standards Act.

Many organizations might classify this position as an engineering grade. At Minneapolis-Honeywell, certain top technician grades are also exempt. Our Senior Technician classification affords salary opportunities which compare favorably with our basic engineering classifications. Further, there are promotional opportunities for qualified engineering aides to enter the professional engineering structure.

One problem which I'm sure you're all familiar with is the relationship between the aide and the engineer. The engineer needs training so that he can assign work to make the aide fully effective and not to water down the job making it clerical nor to load on responsibilities beyond his capabilities. The technician also needs training regarding his relationship with engineers.

Classification of Engineering Aides

Between the two extremes of the craftsman and the true engineering aide lies a continuum which can be subdivided in many different ways, each way defining a different type of technician engineering aide. There are at least three main ways of subdividing the engineering aide job. According to the type of industry is one possibility. For example, the chemical industry may require different types of technicians than the aeronautical industry.

A second method, once the industry is selected, is the type of engineering performed for a given industry. These types of engineers might be research, development, design, test, production, and field. I believe, however, the engineering aide position is generally confined to the first three. Each would have different requirements for its aides. The job of an aide to a research engineer may not have the identical requirements as the design engineer aide's job, yet both may have equivalent levels of skill required to do his job if the jobs are equally comprehensive. Conversely, it may be possible that a development engineering aide may be similar or even identical to a design engineering aide.

The final method involved in defining the aide's position is the work itself—having already determined the industry and the type of engineering to which the aide is assigned. Unfortunately, there are so many different types of tasks to be performed and the ways of combining these tasks into specific jobs are countless. Let's look, then, at some examples of research teams in industry.

The Research Team

The leader of the team is the research engineer; the types of technicians assigned to the team depend greatly on the type of work the research engineer does. If I can be permitted some liberties, I'll consider a composite research engineer in a

manufacturing concern such as our Aeronautical Division, with a wide range of analytical and experimental duties. The technicians on the team may range from the craftsman or model maker to the true engineering aide, both of whom have been mentioned before. The model maker may be part of a pool, and not specifically attached to the research team. The same is true of the detail and layout draftsmen who are quite frequently part of a drafting pool rather than assigned to a single research group. The design draftsman, however, may be actually a part of the team.

Aside from the research engineer, who supplies the direction, three of the team members I'd like to discuss in more detail are the research technician, the computist, and the research aide.

The research technician is an important part of the team primarily as a fabricator. He may have either mechanical or electrical skills. The mechanical technician is skilled in the use of many hand and machine tools and can work from the verbal instructions of the engineer, or from rough sketches in which many or even most of the dimensions are missing.

The electronic research technician may be asked to build an amplifier having a certain gain. He will then design the circuit, make the parts lay-out, and actually construct the amplifier himself. He may also test it. In the case of a complicated amplifier, involving highly analytical techniques, the engineer will have to do the theory and design, but the electronic technician would also assist in the experimentation by building models, performing tests, and supplying his experience and know-how whenever required.

Many of the characteristics required of this research technician are somewhat obvious from his duties. Foremost is his education. Since his job is comparatively high in the manipulative skills, one would expect that the trade school type of training would be of as good advantage as the technical institute. In either case, a high aptitude in the manual skills is demanded.

Overall, the requirements are: some education in science and mathematics, some shop practice, specific training in the chosen field, and several years experience under proper guidance. Whether the man's education be trade school or technical institute, the type of work he will gravitate into will depend to a large extent on his aptitudes, interests, and the particular situation in which he finds himself.

Some years back our company performed a small scale statistical check on the correlation between job performance and certain inherent personal characteristics. A group of fifty engineering and research technicians were carefully rated by their supervisors and divided into two groups: above average in performance, and below average in performance.

The raw scores of these men on the Otis General Ability examination were checked and averaged and it was found that the better performers had substantially lower raw scores. The conclusions drawn from this particular study were that tehnicians who scored between 100-125 on the Otis were more likely to be good technicians than those who scored higher than 125.

Another check made was on the scores made by the same group of men on the Physical Science Comprehension test. This examination gives an indication of a person's understanding of physical phenomena. Here again, those with the lower scores turned out to be the better technicians. What general conclusions can be drawn from this I cannot say, because I'm not a psychologist. One might say in summary, though, that those with lower general ability scores and somewhat less aptitude for physics may find greater personal success in the technician field than those with higher potential. The latter group, provided they have other proper aptitudes and interest, may find greater challenge and success in work more closely like engineering.

The Computist

Another research technician is the computist. This person's tools of trade include the calculator, the slide rule, mathematical tables, and charts. He may perform simple arithmetic operations or may solve rather complicated mathematical expressions. Some computists also do coding and simple programming for large-scale digital computers. Others may do circuit layout for analog computer studies and help with or do the programing board wiring. Requirements for this position include mathematics at least equivalent to two years of engineering college. Some have BA degrees with a major in mathematics. Ideal characteristics are patience, persistence, and accuracy in working with numbers. Many women find employment in this area.

The Research Aide

The technician bordering on the true engineering aide requires considerably more of the technical institute type of training wherein considerable emphasis is placed on the basic sciences, mathematics, and techniques of engineering. Some of our temporary jobs in this area are filled by undergraduates in engineering who have had at least two years of college. While the work performed by this type of person is quite broad, one of the most common of our research aides is what might be termed a computer technician or computer operator. He works closely with the engineer in solving complex mathematical problems relating to actual systems on an analog or digital computer.

With his mathematical and physical background, he is able to set up problems on the computer from the mathematical expressions of the system to be solved. In some systems, which are repetitive in nature or similar to other systems, he may actually derive the mathematical equations. The aide may set up the problem on the computer, which involves wiring the patchboards, or he may turn the job over to another technician, such as the computist, to do the wiring. This is a very painstaking job and requires a great deal of accuracy, thoroughness, and self-checking to see that the problem is correctly wired up. If a mistake were made in the wiring, it might take many hours or even days to trace the trouble.

The research aide may also run the problem on the analog computer. The requirements of the problem are generally outlined by the engineer, but it is up to the research aide to follow through and get the proper data. In the case of problems which are analogous to previous ones, the technician may be able to set up his own

test schedule and perform the computer operation. The aide will help the engineer in analyzing the test results, may contribute to certain parts of the report, and assist in getting the report published.

Other types of research aides may assist the engineer in setting up test programs and actually run through tests on experimental or actual equipment, or may check drawings, make drawings, or perform studies for engineers. The characteristics of this type of job require, as you can see, a strong background in mathematics and the sciences, and considerable background in engineering fields.

I believe that all three of these jobs, the research technician, the computist, and the research aide, because of their close association with engineering work, all have opportunities to make increasing contributions. Those who are willing to continue their study and seek out progressively challenging assignments are certain to find themselves being given more responsibility.

Summary of Characteristics

Education. The education of the technician must cover three broad categories: mathematics and science, shop practice, and the technician's specialty. Depending on the school he goes to, one or some of these may be stressed more than the others. Depending on the job he selects, he may have to supplement his education in one or more of these areas. The research aide will have to have greater emphasis on the science, mathematics, and engineering theory.

Experience. As in any other field, experience is important and the more experience a man can get the more valuable he becomes. Before a technician can be properly classified as a research or engineering aide he needs the educational background and several years of practice.

General Ability. While it covered only a small group of technicians in a specific occupation for a particular industry, our study showed that those with a raw score between 100 to 125 (average 116) had a greater chance of success in this occupation than others with lower or higher scores. I do not believe that I can quote test figures which can define the potential success for an engineering aide. I feel safe in saying that he requires above average general ability.

Engineering Aptitude. It seems to me that an engineering aide should have a fairly high degree of engineering aptitude, and probably higher than that of the average technician. Many tests are available which give some indication of this aptitude. A high engineering aptitude does not necessarily mean that a man will make a success as an engineering aide, but it could be significant.

Ability to Get Along with Others. As an engineering aide a man will have many contacts, many more perhaps than a technician working in a pool. He needs, therefore, the ability to get along with others and to communicate with others. I have heard it said that more people lose their jobs because of the inability to get along with others than from their inability to perform their job.

The engineering aide not only has to get along with the engineer, but he may also have frequent contacts with Drafting, Model Shop, Factory Contact, Production, the Library, Specification Engineers, and Purchas-

ing. To be fully effective, compatibility must be two-sided, and a man with a desire to work effectively can greatly offset the incompatibility of others. I place this trait high for the engineering aide.

Thoroughness. Under this heading several things might be placed, accuracy, attention to details, and completeness, to name a few. These traits are all important, though they may vary in relative importance depending upon the job.

Responsibility and Drive. I have placed these two factors together, because they are closely related. It is important for the aide to keep up with technological advances. For this he needs drive, he needs the desire to get ahead, and to do so he must be able to accept responsibility. The engineering aide must not be too zealous, however, so that he takes on responsibility before he is ready for it.

Undoubtedly there are other characteristics which might be unique for the engineering aide. The several jobs that an engineering aide can hold are quite varied, and the characteristics required of him for a particular job may be more related to the job itself. Hence, on-the-job training may develop proper characteristics faster or easier than what might possibly be taught in an educational institution.

Conclusions. First, proper selection must be arrived at so that the students enrolling in the technical institutes and trade schools have the proper engineering aptitudes, have above average general ability, interest in technical subjects, and a reasonable interest in people. Then the basic sciences, mathematics, shop skills, and technical skills can be taught. Then an understanding of the need of accuracy, thoroughness, completeness, and the relationship of the technician to the engineering team must be given. If both of these things are done, there should be no worry about developing properly qualified engineering aides.

EDUCATING INDUSTRIAL MANAGERS FOR TOMORROW

W. W. McCALLUM

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An address given at the joint luncheon of the Chemical, Civil, Electrical, Industrial, Mechanical, and Engineering Economy Divisions on June 27, 1956, Ames, Iowa.

Most business leaders agree that industry's principal problem today is the shortage of qualified people to fill executive positions. Unless concentrated action is undertaken to provide adequate personnel, our industrial economy, as well as our standard of living and our national security, will suffer in years to come. As a result of our ever-expanding industrial economy, we must have an ever-increasing supply of trained young people, qualified to fill the demand of business.

Without question, the opportunities for engineers in management are many, but we should consider whether or not engineers are being properly educated for these positions. First, however, it is important to analyze the qualities and knowledge necessary to direct a business successfully. The basic qualities needed are the same whether the business is large or small. Most courses of training in our universities qualify individuals for specific fields, but do not necessarily qualify them for the broader requirements of management.

Obviously, it is impossible in the time allotted to discuss *all* of management's responsibilities. I would, however, like to discuss *some* responsibilities that I feel students could be more adequately trained for in the technical and scientific curricula of our universities and colleges.

I recognize that a certain percentage of engineering students expect to confine their careers within the purely technical aspects of their fields. However, few actually are qualified to make a final determination of their lifetime work when they have been exposed only to the educational and technical aspects. Unless engineers have some training in the over-all phases of management, they will not be prepared for the opportunities that present themselves during their business careers and may be forced to remain in technical positions even though managerial opportunities are available.

Too often there is a horizontal movement of individuals from firm to firm. This stratification of personnel into frozen classes is a real peril in modern business organizations, and can be attributed to inadequate training and employee selection at some earlier period. A discouraging fact about the stratification of personnel is that it dulls the ambition and initiative of employees in secondary positions of responsibility. These individuals must be made to feel that there is something better in the future—something for which to strive.

I wonder if the tendency for engineers and scientists to remain in strata below that of management has played any part in the failure of our country to keep pace with certain other countries in the education of engineers and scientists. Just the other day I was surprised to learn that at present only 16% of our university students major in science or engineering compared to 20% in 1950.

Russia is far ahead of us in training engineers. Over the past five years we have graduated only 142,000 engineers, compared to an estimated 216,000 in Russia. In the next five years our projected output is 153,000 against at least 400,000 in Russia. In Russia 30% of the college students are in engineering compared to 8% in this country currently.

I have been informed that less than half of our high schools teach courses in physics and chemistry, while 40% of all Russian high school instruction is devoted to science. We cannot afford to have this trend continue. Our national situation demands that we find out why our scientific development is not moving as fast as Russia's. Your association should give grave consideration to solving this problem.

Human Factors

Certainly as important as the material makeup of a business is the human factor or—to put it more plainly—the people. It is very important that we all be brought to the stern realization that the political and economic world supremacy of this country no longer rests upon our rich natural resources. It is based upon the ability of our people. We must find ways of developing this ability.

The more experience one has at any level of management, the more conscious one becomes that the success of any enterprise is dependent upon the characteristics, behavior and attitude of employees from the common labor through top management. It must be understood by all that the human dignity of those entrusted to their direction must be preserved at all times.

When any executive stops to analyze how his time is spent, he generally will find that the human element of his business is the most demanding. In practically every move we make, the effect upon employees or consumers weighs heavily in the decision. Therefore, it is important that any young student with ambition to take a place in management should be able to direct his educational program in a manner that will give him as much background as possible in the social sciences.

Recently I spoke to a group of Iowa businessmen and stated that one of the major problems of any business is to establish a sound labor-management relationship. Statistics show that over 50% of all engineers become junior supervisors in industry shortly after beginning their business careers. I would like, therefore, to discuss the importance of training in labor-management relationships.

We in large industry have already crossed the bridge to recognizing that we have and will continue to have unions representing production employees. I believe a large plant is much better off if it has a strong union with capable officers elected by well-informed employees. One of the currect problems in this connection is the lackadaisical attitude of union members toward the conduct of union affairs. It is the responsibility of both company executives and union officials

to stimulate a continuing active employee interest in trade-union matters.

One of the basic fundamentals of unionism is the grievance procedure. In large measure, a sound labor-management relationship is dependent upon the prompt handling of grievances at the level of assistant foremen or foremen and employees and stewards. How can we expect a young engineer, starting out in a plant as a supervisor, to be able to handle the labor problems of his department when he has had no training in labor-management relationships? He must deal with plant stewards who, in many instances, have been raised in the union movement and are well experienced in matters attached to the practical use of grievance procedures.

While top management can establish labor policies, it must depend upon the front-line supervisory group, which deals directly with employees, to carry out these policies and to establish the proper attitude on the part of employees. You must agree that sending your graduates into industry with little or no training in industrial psychology or labor-management relations is not practical and can result in failure.

It will be recognized that the management-labor problem is one of human relationship. This field of human relationship is broad and extends even into the community, where the importance of the relationship between business and the community is becoming more and more apparent. All employees, and especially management personnel, should be encouraged to participate in community affairs and cement this relationship.

Engineers are qualified to participate in community planning activities, but often are lacking in the human approach to community affairs. An individual's success in the field of human relations is largely dependent upon education in social sciences and the experience obtained through extra-curricular college activities. A student's educational program should not be so confined to technical training that there is no time to broaden his range of interests. We must realize that human relationships in any occupation are as important as technical knowledge.

In all of our daily activities we are faced with the problem of being salesmen, of selling our ideas to our associates who have both greater and lesser responsibilities. Experience has shown that the many engineers in our company, as well as others with whom I have been associated, have more difficulty in selling their ideas than do men in other fields. It may be that engineers become too wrapped up in the mathematics and technical factors involved in their positions, and fail to recognize the necessity of selling their ideas to those making final decisions. Full consideration should be also given to training engineers in the presentation of ideas through such means as courses in public speaking and report writing.

Also, is it not reasonable to expect that engineers should understand the cost factors of their projects and costs in relation to financial return? They should have a basic understanding of cost accounting and financial accounting. The lack of training in accounting is a great handicap to many business and professional people; this weakness in our educational system is not limited to our engineering colleges. I don't advocate that this training should reach the higher levels of accounting, but certainly a basic knowledge would

be helpful and would give foundation for later study if deemed necessary.

Training in economics is of major importance to anyone wishing to fill a responsible position in business. Recently I had a conversation with an economics professor responsible for instructing engineering students. I was amazed to learn that the only students attracted to his classes were the relatively few who had completed their basic engineering requirements for graduation but had a few open hours in their last quarter.

The function of management is to make decisions, and economics is the science of decision-making. The major problem of decision-making is dealing with the unknown. There are no precise laws which will permit one to foresee the future, yet managers must make decisions regarding the future based upon the present information available. Since most engineering students are taught to apply fairly precise physical laws to the engineering problems facing them, it is not unexpected that they would have difficulty in making policy decisions. Some training in economics or decision-making is almost a must for management. Engineering students should be required to take extensive work in economics even at some loss of technical training.

Certainly decision-making is the main function of management at all levels. Making day-to-day decisions generally is not too difficult because of the current nature of the facts upon which such decisions are made. The difficult decisions are those related to planning the future of business. A business cannot remain static—it must move ahead or it is bound to regress. Some business executives of my acquaintance purchase large insurance policies to cover the loss of top personnel. Most of these executives purchase large insurance policies to protect the future of their families. Yet, these same men do not protect their businesses by careful future planning.

Future planning must cover such matters as adequate working capital and adequate personnel at the management level. We must examine the problems and opportunities that will face us in future years and we must remember at the outset that a decision which is best for current operations is not always best in the long range.

Another important factor in long range planning is risk taking. Actually, it is uncertainty or noninsurable risks with which management must cope. Decisions must be made on the basis of the probability of success.

It has been said that the prime requisite of management is vision. The hallmark of vision in the ability to change or predict with clarity and confidence the needs of tomorrow and beyond tomorrow. It is the person who is trained to study the factors known today and project them into the future who is most likely to have this required vision. Long range planning, however, must be larger than just the wisdom to anticipate future changes. Business leaders must have the courage to act upon the future needs of the company. So we must have vision coupled with action.

One inevitable result of acting upon anticipated changes is the margin of error. One way to avoid making errors is to make no decisions, but no company can afford *this* mistake. Management will make some bad evaluations and some decisions that will affect the company adversely; it must be prepared to withstand and rectify these mistakes. We must be able to appraise the attitudes of people and their out-

look on life so as to be ready for changes that are certain to occur under our economic and political structure. We must be prepared to take advantage of these changes.

I have tried to give you a few of the problems of future planning to stimulate your thinking as to the type of preparation students should have if they are to take an active part in decision making. I wonder if graduates of the 1956 engineering classes *have* been trained with the view that eventually they may play a large part in the direction of a business?

Is it not somewhat discouraging that, on the whole, engineering students start at the higher levels of salary but in time seem to fall by the wayside in the salary and management position categories? Could this be due to the restricted nature of the present engineering educational programs? Is it possible that we will find more and more students backing away from the engineering and scientific subjects and pursuing those that apparently have a greater long range financial return? Has this contributed to the decline in the percentage of students entering the engineering and scientific schools?

I wonder if engineering educators are wise in fostering the generalization that only an exceptional student can obtain a degree in this field. Does the fear of failure cause many students to seek other fields even though they may have the ability to earn a degree in engineering?

One only need look at the recent growth in population to realize what demands will be put upon our industrial economy in years to come. As recently as 1950, forecasters were estimating a population of 170 million in this country by 1956. Already we have 169 million people and our population is increasing by approximately 2% per year. Indications are that this growth will be maintained.

If we are to maintain our current standard of living, productivity must also increase by 2%, or our plants must expand by 2%. There is no question that industry has been expanding and keeping pace with the increase in population. For example, the aluminum industry has doubled since 1951. Yet, it plans to expand another 50% in the next few years. The steel industry will add five million tons of new capacity annually during the next three years, an increase of two-thirds over the annual expansion of the past ten years.

In considering the greater needs for supervisory personnel, one also must consider the present political situation. Both political parties are committed to an era of full employment, and our government certainly will attempt to accomplish this through appropriate monetary and fiscal policies. Thus, we are bound to have a constantly expanding economy that will create an ever-increasing demand for qualified personnel.

In Summary

We have considered the need for preparing students for management and possible changes in the engineering curriculum. In many cases these suggested changes would add to the present academic load. Although one solution would be to extend the degree requirements over a longer period of time, I do not wish that; perhaps a shift in emphasis in training before and after graduation is warranted.

Industry can be helpful by participating in college planning programs.

Our own company recently has initiated such a participation with the agricultural colleges in our area. We have taken a group of our management personnel, selected from all fields, to several colleges, discussing with students and faculty the general aspects of business and our own industry. We presented our company's organizational charts and a brief review of the economics of our products. The presentation was followed by a discussion period.

At the conclusion of the meeting, we found that the students interested in any particular subject searched out our representatives for further discussion. We have been pleased with the reaction of the students and faculty on these occasions. They appreciated the opportunity to discuss business management with a group such as ours. If industry recognizes its responsibilities to our colleges and universities, it should be willing to devote the time required to give students and faculty an insight into management problems.

We in industry recognize our responsibility to *continue* the education and training of our employees as well as to participate in college training programs. In general, it may be better for colleges to give students the broader training I have suggested, and to let industry assume partial responsibility for the technical training which would have to be sacrificed in the classroom.

Those familiar with the vast industrial development of our country should not be critical of the engineering and scientific educators. You people must feel a great satisfaction in watching the students that you taught contribute to this great industrial development. But, like industry, a profession does not stand still. It either progresses or regresses. Thus, you should not become complacent with your success. You must always look to the needs of the future. You have the responsibility of constantly evaluating and changing your programs to anticipate and cope with changing conditions.

.....YET-ITUDES

VIEWS AND NEWS CONTRIBUTED BY

The Young Engineering Teachers

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ASPIRIN FOR A TEACHING HEADACHE

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University of Wyoming, Laramie

The following article is the author's condensation of a paper written for the YET contest, Rocky Mountain Section, 1956.

During the writer's undergraduate days and later as an instructor, there was a particular headache which stood out above all others – poor morale in laboratory courses. Even more important was the resulting ineffectiveness of laboratory teaching. As a student, laboratory courses were something to be dreaded; as an instructor, the situation was even worse. A test had to be started from scratch and completed in one three-hour period, regardless of what happened, with the initiative and responsibility falling entirely on the instructor's shoulders. The test assignments, in the words of the students, were strictly "snow jobs"—a lightning lecture at the beginning of the period on what was involved and what data to take, followed by a horse whipping through the actual test to finish by the end of the period. This often resulted in befuddled students with something less than good data on which to base the calculations and the report.

A situation of this type is extremely undesirable for several reasons. The time spent by the students in the laboratory is poorly invested if not used efficiently. Moreover, the student may not develop an appreciation for experimental work which certainly is as important as analytical work.

On the teaching side of the problem, the poor morale results in many members of the teaching staff taking the attitude that laboratory teaching is something to be avoided at all costs and living only for the day when they have enough rank and seniority to retire to the world of the textbook alone. Of course, this attitude may be explained in part by the fact that it is considerably easier to have chalk and textbooks primed for activity than a piece of laboratory equipment. The important point, however, is that it is a mistake to have the most experienced men divorced from laboratory teaching. These men are certainly best qualified to stress the fundamentals in a particular application

and should be well able to impart their natural enthusiasm to a group of students. Wouldn't it be a big step forward if laboratory morale could be improved to the extent that students would have a spirit of real participation and faculty could derive as much satisfaction from teaching laboratory as they do from lecture courses?

An opportunity to try a different approach fell to the writer when he recently returned to teaching and was asked to assume the laboratory responsibility. The principal laboratory course came in the senior year following a junior laboratory course which combined measurements and report writing. It was felt that with this background in addition to thermodynamics and fluid mechanics, a senior mechanical engineering student should be able to carry out basic test assignments on conventional mechanical machinery with a minimum of supervision. With this in mind a system was devised wherein the students are given a semester assignment sheet consisting of four assignments with no strings attached to the time distribution. This generally works out so that each group spends about four laboratory periods (12 hours) on each assignment. The assignments must be staggered when two or more groups are handled simultaneously.

The following procedural outline is given to each student and is followed for each assignment:

1. A group leader will be designated whose job it is to correlate the group's entire activity and to bring the group together with the instructor for the required conferences.

2. A test will be assigned to the group; e.g., Determine the variation in brake thermal efficiency with varying compression ratio from 5 to 12 on the Waukesha Cooperative Fuel Research engine operated at a constant speed of 1,000 rpm.

3. The group should then evolve a schematic sketch of a proposed test rig, including auxiliary apparatus and instrumentation. This must be done without reference to the actual machine in the laboratory since the "on the job" situation certainly would not be all set up ahead of time as it is in our laboratory. When the group is agreed on the set-up, the instructor is to be notified and the group leader is to go through the proposed set-up on the blackboard. Necessary revisions will be brought out at this time by discussion.

4. The group should then become thoroughly familiar with the apparatus to be tested. This can be accomplished by visual inspection, study of manuals, and filling out question sheets. A conference should then be held with the instructor to discuss the details of the apparatus, how it is to be operated, and what limitations must be imposed on operation. This conference should be culminated by a demonstration running of the apparatus by the students and instructor to further familiarize the students with the apparatus.

5. The group should then plan their test, submitting a written outline of the test, including what data are to be taken and the range of the independent variable. The third conference should then be held to go over the test outline with the instructor. This is simply to check on limits of operation, eliminating damage to equipment from excessive speeds, for example. It is the group's responsibility to be sure the data are complete and, therefore, nothing will be said if the test plan is incomplete.

6. The group should proceed with the test and data recording; the original copy of the data sheet is to be submitted to the instructor.

7. The group should complete the calculations and then submit a set of penciled curves to the instructor which will be filed along with the original data sheet. At this time the fourth conference is to be held with the instructor to discuss the results.

8. The test should be written up individually following the prescribed report form and is due one week from the day the curves are submitted.

The group leader system has proved quite satisfactorily. It helps to have one individual who must take responsibility. It is very gratifiying to see some of the students really step in and lead; true, some don't work out well as leaders, but these are definitely in the minority.

The instrumentation session has proved to be the most beneficial departure from conventional systems. There is much to be gained when the students have to make instrumentation decisions and therefore occasional mistakes.

The familiarization procedure also fills in a big gap. One of the most common pitfalls in teaching occurs when an instructor has been over the ground many times and just can't bring himself down to the level or the speed of the student. This can happen in laboratory teaching as well as classroom work.

Evidence that student planning can be effective is that, to date, no group has neglected to collect a single item of essential data. This is quite an improvement over a situation where the instructor has to worry about whether or not he remembered to mention every item of data to each section.

In general, the objective of shifting the initiative to the student, and thereby improving morale, has been accomplished. It is a real joy to see these student groups pitch in and *run* a diesel engine heat balance, for example. This is not an easy assignment, but with this procedure the students know what they are doing and why, and act accordingly. In addition to the marked improvement in laboratory attitude and interest on the part of the students, the instructor's morale on the teaching end is vastly improved, which is also worth while.

GENERAL ELECTRIC SUMMER PROGRAM OF INTEREST TO YETS

THOMAS A. BOYLE
Chairman, CYET

Attention YET Sub-Chairmen

The General Electric Company is in the process of changing its summer program for college teachers, primarily for the benefit of Young Engineering Teachers. Heretofore the program has been primarily for established professors with well-developed fields of specialization. Present G.E. plans indicate a program which will cater to the needs of Young Engineering Teachers who wish to develop their abilities along professional lines.

In particular the program covers a ten week period in which a teacher can gain engineering experience and also participate in a two week conference program. This will include desirable features from the many conference programs which G.E. has conducted over the years. Full details cannot be included but suffice it to say that this program appears amply rewarding from the financial angle as well. Those responsible for the program have sought the help of the CYET in the hope that by working together we can facilitate the contacting of young teachers who are interested in this type of experience. It is our joint hope that other organizations will follow along the lines which are being set up.

Your Responsibility

The job for you is *to obtain the names of YET's* in your section who would be interested in the program. Please forward the names of these men, together with some indication of their interest, to: Professor Harold A. Foecke, Vice Chairman CYET, Department of Electrical Engineering, University of Notre Dame, South Bend, Indiana. Foecke will send these names to the company and G.E. interviewers will then take over, so it will help if the names can be obtained promptly. The names will also be available through YET to other organizations offering similar opportunity.

I consider this a real opportunity for the Committee for Young Engineering Teachers to help in a significant way. Please do all that you can to obtain names of interested teachers in your section and forward them to Harold Foecke just as soon as possible.

TEACHING POSITIONS AVAILABLE

The Teaching Positions Available department is published as an opportunity and convenience for Active and Affiliate Institutional Members. By action of the General Council, a nominal charge per line is made. Inquiries about rates, replies to coded advertisements, and correspondence concerning the department should be directed to the JOURNAL, 114 Civil Engineering Hall, University of Illinois, Urbana.

ASSISTANT OR ASSOCIATE PROfessor in Industrial Engineering. Need experienced man from diversified industries in production planning and control, tooling and mechanization, and other production areas. Cooperative industries assist research facilities in these areas. Advanced degrees helpful. Excellent consulting opportunities, beautiful campus, 9 month contract, salary open. Some teaching experience desirable; can develop new courses. Write Department of Industrial Engineering, Washington University, St. Louis 5, Missouri.

ASSOCIATE AND ASSISTANT PROfessors for fields of advanced strength of materials, elasticity, dynamics, and fluid mechanics. Start February or September. Department of Applied Mechanics, University of Kansas, Lawrence, Kansas.

VISITING LECTURER OF ASSOciate Professor level needed on January 2, 1957. Must be graduate of accredited Industrial Engineering curriculum and have had 5-10 years industrial and teaching experience. Will be required to teach statistical quality control, factory planning, engineering economics, etc. Opportunities available to teach night course and to conduct private consulting practice. Good opportunity for advancement. Write Director, Dept. of Industrial Engineering, University of Puerto Rico, College of Agriculture and Mechanic Arts, Mayaguez, Puerto Rico.

INSTRUCTOR OR ASSISTANT PROfessor to teach mechanics, dynamics, vibrations, stress analysis. Master's degree and some industrial experience preferred. Mechanical Engineering Dept., Oregon State College, Corvallis, Oregon.

ELECTRICAL ENGINEERING AND Teaching Fellowships in large urban college. Part-time day teaching with tuition-free evening graduate work toward M.S. in Electrical Engineering. Summer employment available. Excellent opportunity for B.S. graduate who wants training for full-time engineering teaching. Salary increases and promotion on attainment of M.S. Also full-time teaching or part-time teaching plus part-time research available in ranks of Assistant Instructor through Assistant Professor. Annual salary increments. Evening teaching, graduate, and undergraduate, available with extra pay. Summer employment available. Apply to F. A. Russell, Acting Chairman, Department of Electrical Engineering, Newark College of Engineering, 365 High Street, Newark 2, New Jersey.

ASSISTANT PROFESSOR OR INstructor, rank dependent upon education and research activity, to teach fundamental courses in mechanics, structures, or soil mechanics. Exceptionally light teaching loads. Excellent opportunities for research. Applicant for Assistant Professorship should have Doctorate in applied mechanics or in structures, for Instructorship should have M.S. or equivalent in graduate study. Instructor expected to pursue study for Doctorate. Opportunity for summer employment on sponsored research at University or in industry in vicinity. Leading university. Location large metropolitan area, mid-

Atlantic. Position available February, July, or September, 1957. Send resume. JAN.-1.

ELECTRICAL AND MECHANICAL Engineering staff openings at Ph.D. and M.S. levels. Salaries commensurate with qualifications. Apply to Dean of Engineering, Duke University, Durham, North Carolina.

ELECTRICAL ENGINEERING staff positions available at all academic levels. Senior staff with power systems experience is needed to assist in applying digital computer techniques to power systems analysis. Additional staff is needed for graduate and undergraduate instruction. Research and graduate study opportunities are available. Apply to Attie L. Betts, Professor and Chairman of Electrical Engineering, Washington State College, Pullman.

ELECTRICAL ENGINEERING PH.D. needed for teaching undergraduate courses and developing graduate courses. Demonstrative leadership can lead to Chairmanship. Competitive salary. Liberal research and consulting policy. Send resume to Dean of Engineering, University of Toledo, Toledo 6, Ohio.

INDUSTRIAL ENGINEERING ASSISTant Professor to teach methods and standard courses and to work in basic manufacturing processes course, starting September, 1957. Must have graduate degree; industrial experience desirable. Opportunity for further graduate study. Apply to Chairman, Division of Industrial Engineering, University of California, Berkeley.

CIVIL ENGINEERING RESEARCH and teaching positions available. Two vacancies for Assistant or Associate Professors, salaries on twelve-month basis. Part-time research and part-time either graduate or undergraduate teaching. Ph.D. preferred, M.S. acceptable. Candidates must have special training or experience in Highway Engineering or in Structures. Department of Civil Engineering, Alabama Polytechnic Institute, Auburn.

ENGINEERING TEACHING STAFF openings at the ranks of Instructor, Assistant Professor, or Associate Professor in Mechanical Engineering. For further particular write to Dean of Engineering, University of Nevada, Reno.

MECHANICAL ENGINEERING, Fluid Dynamics, Electrical Engineering, Physics, and Mathematics teachers needed. Advanced degrees required. Write to President A. B. Bronwell, Worcester Polytechnic Institute, Worcester, Mass.

ASSISTANT AND ASSOCIATE PROfessors of Engineering needed. Able young Ph.D.'s interested in teaching and research in equal amounts. Well equipped and active professorial staff in thermodynamics and fluid mechanics is expanding to size comparable with internationally-known group in mechanics of solids. Excellent opportunity for development and advancement. Write to Professors J. Kestin, P. F. Maeder, or R. F. Probstein, or to D. C. Drucker, Chairman of Engineering, Brown University, Providence 12, Rhode Island.

ASSISTANT AND ASSOCIATE PROfessors of Engineering interested in teaching and research in equal amounts. Electronics and circuit men preferred to help complement group in electromagnetic theory. Excellent opportunity for development and advancement for qualified young Ph.D.'s. Write to Professor C. M. Angulo, R. D. Kodis, or E. T. Kornhauser or to Chairman of Engineering, Brown University, Providence 12, Rhode Island.

ASSOCIATE PROFESSORS, ASSISTant Professors, or Instructors to teach in the Department of Engineering Drawing, which supervises courses in Graphics, Engineering Mechanics, and Engineering

Orientation. Rank and salary determined by training and experience. Year-round opportunities for participation in research which replaces part of teaching load during the academic year. Apply to Professor Carson P. Buck, Chairman, Department of Engineering Drawing, Syracuse University, Syracuse 10, New York.

MECHANICAL ENGINEERING POSITION available as Assistant or Associate Professor. Advanced degrees required. Unusual opportunity to take a leading part in the development of graduate program. Write to Dean of Engineering, University of Virginia, Charlottesville.

ELECTRICAL ENGINEERING teaching positions will be available. Rank and salary commensurate with qualifications and experience. Opportunity for graduate study. Address inquiry to Dr. C. Froehlich, Department of Electrical Engineering, City College of New York, Convent Avenue and 139th Street, New York 31, New York.

STEINBERG APPOINTED PRESIDENT

S. S. Steinberg, former Dean of Engineering at the University of Maryland, has been appointed President of the Technological Institute of Aeronautics at Sao José dos Campos, Sao Paulo, Brazil. The objective of this new government-sponsored civilian university, which was founded in 1950, is to train engineers and technicians on all levels to help develop Brazilian aviation. A member of ASEE since 1935, President Steinberg served as Vice President of the Society, 1947-49, and as a member of Council, 1946-48 and 1949-50.

ENGINEERING AND SCIENTIFIC MANPOWER

The U. S. Office of Education recently published a circular, "Engineering and Scientific Manpower—Organized Efforts to Improve Its Supply and Utilization," by Henry H. Armsby, Chief of Engineering Education, Division of Higher Education, U. S Department of Health, Education and Welfare. It lists the 14 nongovernmental organizations, 9 federal agencies, and 2 presidential committees most actively concerned with the engineering and scientific manpower situation, describing briefly what each is trying to do about it, and giving an idea of the interrelations among the many agencies involved. Copies of the 48-page Circular No. 483 can be obtained from the U. S. Office of Education, Washington 25, D. C.

NEW MEMBERS

ALEJANDRINO, ANGEL A., Instructor in Engineering Mechanics, University of The Philippines, Manila, P. I., L. G. Straub, A. G. Anderson.

ANDERSEN, LAIRD M., Assistant Professor of Chemical Engineering, Lehigh University, Bethlehem, Pennsylvania, R. H. Snyder, W. J. Eney.

BARDES, OLIVER P., President, Engineers' Job Directory, Cincinnati, Ohio. W. D. McIlvaine, Jr., H. P. Rodes.

BATTOCLETTI, JOSEPH H., Assistant Professor of Electrical Engineering, Loyola University of Los Angeles, Los Angeles, California. D. E. Whelan, Jr., J. E. Sakaly.

BROWN, WILLIAM A., Instructor in Civil Engineering, Manhattan College, New York City, New York. V. J. Vitagliano, J. McCabe.

CAMPBELL, GEORGE F., Instructor in Applied Mechanics, University of Wichita, Wichita, Kansas. E. L. Cook, L. O. Hanson.

CARLSON, ROBERT L., Engineering Drawing Department, General Motors Institute, Flint, Michigan. E. D. Black, C. A. Brown.

CHAPMAN, BEN R., Instructor in Mechanical Engineering, University of Maine, Orono. J. R. Lyman, F. J. Sullivan.

CLARK, LLEWELLYN E., Instructor in Mechanical Engineering, University of Maine, Orono. J. R. Lyman, F. J. Sullivan.

CLEVELAND, FRED W. JR., Assistant Professor of Industrial Engineering, Stevens Institute of Technology, Hoboken, New Jersey. A. Lesser, Jr., J. E. Crouch.

CLIFFORD, GEORGE E., Assistant Professor of Mechanical Engineering, University of Maine, Orono. J. R. Lyman, H. D. Watson.

DE COTIIS, JOHN C., Teacher in Chemistry, Board of Education, Jersey City, New Jersey. W. L. Collins, W. L. Everitt.

DEMING, DONALD E., Assistant Professor of Mechanical Engineering, University of Maine, Orono. J. R. Lyman, R. Hill.

DOWNEY, PAUL M., Associate Professor of Industrial Engineering, University of Florida, Gainesville. E. P. Martinson, E. H. Lewis.

EUSTIS, ROBERT H., Associate Professor of Mechanical Engineering, Stanford University, Stanford, California. A. L. London, W. M. Kays.

FERRON, JOHN R., Instructor in Chemical Engineering, University of Wisconsin, Madison. O. A. Hougen, R. A. Ragatz.

FINN, WILLIAM D., Instructor in Civil Engineering, University of Washington, Seattle. D. A. Carlson, W. M. Miller.

GABRIEL, EDWIN Z., Assistant Professor of Mechanical Engineering, Villanova University, Villanova, Pennsylvania. J. S. Morehouse, J. J. Gallen.

GRENATA, MICHAEL C., Instructor in Civil Engineering, Pennsylvania State University, University Park. T. J. Rung, F. B. Fischer.

HAMID, HAMID I., Graduate Student in Civil Engineering, Northwestern University, Evanston, Illinois. W. L. Collins, M. M. Boring.

HENRY, B. R., Associate Professor of Engineering Drawing, Lamar State College of Technology, Beaumont, Texas. R. V. Andrews, G. B. Tims, Jr.

JANSEN, RICHARD J., Graduate Instructor in Mechanical Engineering, Marquette University, Milwaukee, Wisconsin. J. P. Bradish, J. J. Lonergan.

KALETTA, RAYMOND F., Technical Placement Supervisor, McDonnell Aircraft Corporation, St. Louis, Missouri. M. M. Boring, W. L. Collins.

KAUZLARICH, JAMES J., Graduate Fellow, Mechanical Engineering, Northwestern University, Evanston, Illinois. A. B. Cambel, E. F. Obert.

KLEIN, DONALD R., Instructor in Chemical Engineering, Villanova University, Villanova, Pennsylvania. J. S. Morehouse, V. W. Uhl.

LESTER, JOHN C., Associate Professor of Mechanical Engineering, Pennsylvania State University, University Park. E. P. Nye, G. M. Dusinberre.

LORD, ALBERT M., Associate Professor of Mechanical Engineering, Fenn College, Cleveland, Ohio. D. L. Penney, R. M. Hochner.

MEADOR, HENRY T., Assistant Professor of Mechanical Engineering, University of Washington, Seattle. P. L. Balise, J. C. Firey.

MORRIS, SINSEL S., Assistant Professor of Mathematics, Pennsylvania State University, University Park. K. L. Holderman, W. L. Collins.

NERDEN, JOSEPH T., State Supervisor of Technical Institutes, Connecticut State Department of Education, Hartford. W. L. Collins, W. L. Everitt.

PALMER, HARLAN B., Professor and Head of Electrical Engineering, University of Colorado, Boulder. W. J. Hanna, L. A. Bingham.

PENNINGTON, CLARK W., Assistant Professor of Mechanical Engineering, University of Florida, Gainesville. E. W. Jacunski, E. G. Lewis.

RATLEDGE, EARL T., Instructor, Department of Engineering Drawing and Descriptive Geometry, University of Wisconsin, Milwaukee. W. M. Christman, Jr. J. Van Vleet.

REDMAN, GEORGE P., Assistant Professor of Industrial Engineering, North Carolina State College, Raleigh. R. G. Carson, Jr., W. E. Adams.

SAGE, ANDREW P., JR., Instructor in Electrical Engineering, Purdue University, Lafayette, Indiana. S. B. Hammond, J. S. Johnson.

SPINNER, ALLEN H., Associate Professor of Economics of Engineering, Stevens Institute of Technology, Hoboken, New Jersey. W. L. Everitt, W. L. Collins.

STILES, RAIBURN B., Associate Professor of Applied Mathematics, Vanderbilt University, Nashville, Tennessee. G. H. Lundberg, D. A. du Plantier.

STONE, SANFORD H., Associate Professor of Engineering, San Diego State College, San Diego, California. H. L. Stone, C. Morgan.

THEOPHILUS, RALPH H., Associate Professor of Electrical Engineering, West Virginia University, Morgantown. C. B. Seibert, E. C. Jones.

THREADGILL, WALTER D., Assistant Professor of Chemical Engineering, Vanderbilt University, Nashville, Tennessee. F. Schumann, F. J. Lewis.

TODD, FRANK H., Assistant Professor of Physics, University of Maine, Orono. J. Biscoe, C. E. Bennett.

TRESEDER, FRANCIS M., Assistant Professor, Lewis College of Science and Technology, Lockport, Illinois. W. L. Collins, W. L. Everitt.

TU, PING-SHUO, Instructor in Mechanical Engineering, Villanova University, Villanova, Pennsylvania. J. S. Morehouse, V. W. Uhl.

TUITES, CLARENCE E., Counselor, Electrical Department, Rochester Institute of Technology, Rochester, New York. E. M. Morecock, L. F. Smith.

VESPER, DONALD R., Instructor in Engineering Drawing, University of Kansas, Lawrence. A. S. Palmerlee, H. L. Kipp.

VIILO, WESLEY M., Engineering Drawing Department, General Motors Institute, Flint, Michigan. E. D. Black, C. A. Brown.

WESSLER, MAX A., Assistant Professor of Mechanical Engineering, Bradley University, Peoria, Illinois. P. Weinberg, R. E. Gibbs.

WOLFF, MARILYN J., Instructor in Engineering Drawing and Descriptive Geometry, University of Wisconsin, Milwaukee. J. G. Van Vleet, W. M. Christman, Jr.

WOODBURY, ROBERT S., Assistant Professor of History, Massachusetts Institute of Technology, Cambridge. L. S. Bryant, H. R. Bartlett.

ZETTLER, HOWARD G., Instructor in English, University of Colorado, Boulder. W. O. Birk, H. Hawk.

50 New Members
285 Previously Added
335 New Members This Year

ALLAN R. CULLIMORE

Allan R. Cullimore, President Emeritus of Newark College of Engineering, died September 20, 1956, at 72 years of age. A member of ASEE since 1914, President Cullimore served as Vice President of the Society from 1943-44, Member of Council from 1940 to 1943, and in 1941 he was the twenty-fourth recipient of the Lamme Medal. Memorial services are planned for January 20, in the Old First Presbyterian Church, Newark, New Jersey. In recognition of his long service, the most recent building under construction at Newark College of Engineering will be called Cullimore Hall.

ARTHUR L. WILLISTON

Arthur L. Williston, retired Principal of Wentworth Institute, Boston, Massachusetts, died November 16, 1956, at the age of 89. Long active in ASEE affairs, Mr. Williston was currently chairman of the Technical Institute Education Committee. Member of the Society since 1897, he served as Vice President, 1909-10; Secretary, 1907-09; Member of Council, 1900-03, 1905-08; and was the third recipient of the James H. McGraw Award in 1952.

REPORT OF ASEE COMMITTEE ON DEVELOPMENT OF ENGINEERING FACULTIES

HAROLD L. HAZEN, *Chairman*

Dean of the Graduate School
Massachusetts Institute of Technology, Cambridge 39

A major new project of the Society was launched during December when the ASEE Committee on the Development of Engineering Faculties, authorized at the October meeting of the Executive Board and General Council, was formally organized after a series of exploratory conferences. This Committee, sponsored by ASEE, with the support and collaboration of the Engineers Council for Professional Development and the Engineers Joint Council, is charged with the important task of examining the entire problem of recruiting, developing, and utilizing engineering faculties. The project has also received the formal endorsement of the National Committee for the Development of Scientists and Engineers appointed by President Eisenhower.

President Everitt, conferring with the new committee at its first meeting, noted that the Nation's need for more and better qualified engineering graduates is now widely recognized. But, he said, "The urgent problems faced by the engineering colleges in retaining their present staffs and recruiting and developing new teachers from present and future graduates must be solved with vigor and imagination. Unless this is done, the size and abilities of engineering faculties will be the bottle-neck which will limit severely our capacity to provide the number and quality of engineering graduates required now and for the future."

The Committee's assignment to study and recommend solutions to the problem has the Society's highest priority. The Executive Committee for the project, with Dean Harold L. Hazen as Chairman, will soon seek the active assistance of the deans, department chairmen, other administrative officers, and faculty members of engineering schools throughout the country. Working together, the Committee and Society members will attempt to develop effective ways and means of dealing with this critical problem. As the project develops, the Executive Committee will be supplemented by specific working groups and also by a larger central committee.

Other members of the Executive Committee for the project are Joseph C. Boyce, Vice President, Academic Affairs, Illinois Institute of Technology, Chicago; Gordon B. Carson, Dean of Engineering, The Ohio State University, Columbus; Morris D. Hooven, Public Service Electric and Gas Company, Newark, New Jersey (also President of the Engineers Council for Professional Development); and William C. White, Vice President, Northeastern University, Boston, Massachusetts. Executive Director of the Project is Dr. William H. Miernyk, also of Northeastern University.

DEANS' CONFERENCE ON ENGINEERING EDUCATION AND NUCLEAR ENERGY

At the Invitation of the Atomic Energy Commission
Gatlinburg, Tennesee, September 5-8, 1956

RALPH W. MOULTON

Secretary, ASEE Atomic Energy Education Committee
Professor and Executive Officer, Chemical Engineering
University of Washington, Seattle

At the suggestion of the Committee on Atomic Energy Education of the American Society for Engineering Education, a Deans' Conference was held at Gatlinburg, Tennessee, early in September, 1956. This conference resulted from the joint efforts of the Atomic Energy Commission, the American Society for Engineering Education, the Oak Ridge National Laboratory, and the Oak Ridge Institute of Nuclear Studies. The purpose of the meeting was to acquaint engineering deans and presidents of universities and colleges offering programs in engineering with the new and expanding field of nuclear engineering. The program covered various topics, such as manpower needs, the programs at the national laboratories, a tour of the Oak Ridge facilities, the present status of the various nuclear engineering programs at schools throughout the country and a summary of the government aid program. About 300 invited representatives attended.

Manpower Needs

The topic for the first session was manpower needs in the atomic energy program. Mr. Sapirie, manager, Oak Ridge Operations Office, summarized manpower needs at Oak Ridge. He indicated that in the expanded program, students would spend six months at a university or college, followed by six months at ORINS. He was of the opinion that the two summer institutes held during 1956 would point the way for future activities in this field. He also indicated that faculty members had the opportunity for employment at national laboratories during summer vacations.

Mr. Kenneth Colman then discussed manpower needs in the Atomic Energy Program, which were becoming greater month by month. Mr. Colman believed that there were sufficient students entering universities and colleges from high school, but that our facilities for training were not adequate. The Atomic Energy Commission is now competing with other employers for the available scientists and engineers. He said that their surveys were being initiated to evaluate accurately the manpower needs; one will be for industry, one for universities and colleges, and a third for AEC prime contractors.

The next speaker was Mr. P. C. Aebersold, Director of Isotopes Section, Atomic Energy Commission, who summarized the expanding use of radioisotopes in industry and in research. There are now about 1000 different radioactive compounds available for sale. Some of the more important applications of radiation are

the initiation of chemical reactions, the sterilization and pasteurization of foodstuffs and drugs, the prevention of sprouting by potatoes and other vegetables, the use in radiographs and in thickness gauges, and in determining wear on various machined parts. As little as one one-hundred thousandth of an ounce of material can be accurately detected in this manner. The cumulative shipments of isotopes in 1946 were 280, 19,000 in 1951, and 100,000 in 1956.

Mr. Griswold, assistant to the President of the Detroit Edison Company, summarized the needs for personnel in the industrial nuclear power program. He felt that quality was more important than quantity. He said that the needs for technical personnel will become critical during the next ten years. The next five years would probably represent a very rapidly expanding program in the nuclear power industry, which could very well absorb six per cent of the total engineering graduates in this country.

The second session consisted of movies on various topics related to the nuclear industry. Of particular interest to the group was a film entitled "The First in the World," prepared by the Soviet Union. This film presented a rather good picture of a power reactor that has been put in operation in Russia.

The third session dealt with the various programs offered by the Oak Ridge School of Reactor Technology. Mr. Kaufmann introduced this program and expressed the opinion that this field was not a new scientific discipline but rather the joint effort of engineers and scientists working together as a team. Mr. Charpie, Assistant Director, Oak Ridge National Laboratory, discussed the "Aims of ORSORT." He indicated that they had a definition of a "feasibility engineer," who must understand the interrelationships between the various disciplines in order to determine and measure the practicability of a particular design.

Mr. Charpie felt also that manpower needs fall into three categories: highly trained specialists (skilled labor), specialized engineers, and feasibility engineers. He indicated that the ORSORT program was aimed at educating personnel principally in the third category. Dr. Alexander, ORSORT faculty member, next discussed the ORSORT curriculum, and Dr. Pomerance, faculty member, ORSORT, described the four experiments of the laboratory work, using a reactor as a neutron source. Dr. Weinberg, Director, ORNL, summarized the talks.

Fourth Session

The fourth session considered the various programs of the Argonne National Laboratory. Mr. Stuart McLain explained the various types of work being actively pursued at Argonne. He indicated that they would like to have some of the graduates of the 1956 Summer Institute back next summer as employees.

Following Mr. McLain's opening remarks, Mr. Armstrong and Mr. Keller joined in describing, with some detail, the "Argonaut" training reactor developed at Argonne. This reactor is now substantially completed and is expected to become critical this autumn. Designed specifically for universities and colleges, it should be inherently very safe.

Dr. Taecker and Dr. Rylander also described the Argonne program. The original seven-month schedule for international students has now been expanded to nine months. Arrangements have been completed with The Pennsylvania State University and North Carolina State College to take the first four and one-half months of this program. This cooperative arrangement will allow Argonne to double its instructional capacity.

Tour of Facilities

The fifth session, an all-day tour of Oak Ridge facilities, gave the participants a detailed picture of the Oak Ridge Operation. At luncheon, Dr. W. F. Libby, AEC Commissioner, considering the shortages that exist today in the nuclear industries, felt that much could be done to encourage interest in this new industry, and that the Atomic Energy Commission could be of material assistance.

Instructional Programs

The sixth session was a status report on nuclear engineering programs now in existence throughout the United States. The first paper, prepared by Professor Murphy and presented by Dean Smith, summarized existing curricula. Papers were then given by representatives from North Carolina State College, University of Michigan, University of Washington, Massachusetts Institute of Technology, Graduate School of Nuclear Engineering at Richland, and a prediction of future programs by Dr. Boyce of the Illinois Institute of Technology.

At the seventh session of the conference, Dr. Pollard described what AEC contractors are doing to train faculty members. Mr. McMillen next outlined how the National Science Foundation could assist universities by supplying grants for the purchase of equipment and by subsidies to graduate students.

Dr. Walker concluded the final session with a detailed description of the new AEC Educational Aid Program for the next five years. Funds available for the present year amount to about $3,000,000 for equipment and $500,000 for radioactive isotopes and nuclear materials, with an increased appropriation anticipated next year.

It is contemplated that the maximum assistance to any one school will be about $350,000. Money will be made available only for equipment to be used in teaching and laboratory work but not for research, or for buildings, furniture, and personnel. This program is expected to start immediately; Dr. Walker suggested that all institutions interested get their proposals in as soon as possible.

The participants in the conference were very well pleased with the program and felt that the time had been well spent. Many universities and colleges which had lacked contact with nuclear technology in the past were supplied with information about the present status of work in this area, and about plans for the future.

SUMMARY OF SURVEY ON COLLEGE OF PROGRAMS IN NUCLEAR ENGINEERING

CHARLES E. DRYDEN

Associate Professor
Chemical Engineering Department
The Ohio State University, Columbus

A survey of nuclear science and engineering courses taught in the year 1955-1956 was assembled at the request of the Nuclear Engineering Division of the American Institute of Chemical Engineers in cooperation with the ASEE Committee on Atomic Energy Education. The returns from data forms sent to approximately 150 accredited engineering schools in the United States are listed in this survey. The data have been arranged in three groups:

A. Principal courses taught in nuclear science and engineering, preferably by engineering faculty

B. Prerequisite and supporting courses

C. Comments on curricula and experiences in this field of teaching endeavor.

No attempt was made to edit the returns as regards the proper location of courses under A or B category. As an extreme example, some schools listed a full semester of basic heat transfer as a principal nuclear engineering course, while others placed this as a supporting course. Thus, one notes the difference in philosophy which exists nation-wide so that the actual number of primary or principal courses taught at a given institution can be variously interpreted.

From this survey, however, some statistics of immediate interest to educators can be derived:

Number of schools actually teaching nuclear subjects	73
Number of schools preparing to start teaching nuclear subjects	12

Number of Schools Offering	*Number of Primary (Type A) Courses*
22	1
15	2
8	3
9	4
3	5
5	6
2	7
1	8
2	9
1	10
2	11
2	13
1	14
73 schools reporting	269 total courses

A comparison with last year's survey shows nearly a 100% increase in the schools actively participating in nuclear education, with a like increase in number of courses. If five courses or more is arbitrarily chosen as the level for specialization, then we find this year that there are 19 schools in this country prepared for this type of training, compared with five for the previous year.

A further set of statistics shows the trend toward giving courses in a wide group offered by engineering departments. Thus, for the total of 269 courses in all of the engineering schools in the United States, the allocation by departments in which the courses are taught is:

Chemical Engineering	63
Physics	53
Nuclear Engineering	47
Mechanical Engineering	41
General Engineering	38
Management Engineering	11
Metallurgical Engineering	10
Electrical Engineering	8
Chemistry	7
Ceramic Engineering	2
Biology	1
Civil Engineering	1

A booklet presenting the complete data for parts A, B, and C has been published by the American Institute of Chemical Engineers, 25 West 45th Street, New York, New York. Copies can be obtained by writing to that address, enclosing 50¢ to cover handling and mailing.

CAREERS IN NUCLEAR SCIENCE AND ENGINEERING

The Atomic Industrial Forum recently announced the publication of a 34-page illustrated booklet on "Careers in Nuclear Science and Engineering." The booklet is based upon the proceedings of a conference for high school science students which was sponsored by the Forum and the Chicago Junior Association of Commerce and Industry, held in September at the Navy Pier, Chicago, in conjunction with the 1956 Trade Fair of the Atomic Industry and the Forum's annual conference on Management, Economics and Technology for the Atomic Industry.

The booklet contains transcripts of a discussion period in which questions posed by the students were answered by the speakers, who included Dr. Eric Walker, President of Pennsylvania State University, Dr. Lawrence R. Hafstad, Vice President and Director of Research of General Motors Corporation, and Dr. Frederick L. Hovde, President of Purdue University. Designed to interest young people in scientific and engineering careers, the booklet can be obtained at 10¢ per copy from the Atomic Industrial Forum, 3 East 54th Street, New York 22, N. Y.

REPORT ON UPADI MEETING AT MEXICO CITY

Fourth Convention of
Pan American Union of Engineers Associations

RALPH A. MORGEN

ASEE Representative to UPADI
Director, Purdue Research Foundation,
Lafayette, Indiana

The fourth convention of the Pan American Union of Engineers Association was held in Mexico City, October 8-12, 1956. Membership in UPADI is through Engineering Societies in the various Pan American Countries. Delegates are selected from the respective societies to represent those societies at the conventions which are held every other year.

The Engineers' Joint Council is the official affiliated society for the United States to UPADI. Each of the members of the EJC is entitled to send an official delegate and one or more alternates to the UPADI conventions.

At the meeting in Mexico City there were twenty-three delegates and alternates to the convention from the United States. The writer was the official delegate of ASEE, and Dean Lee H. Johnson of Tulane was the alternate delegate.

As officially expressed in the program, the purposes of the UPADI are as follows: "It seeks, for the following purposes, to encourage, promote, orient, lead and inform on the action and practices of the following objectives:

(a) the periodic realization of Pan American Engineering congresses, conventions and expositions, and

(b) to appropriate and coordinate the general relations of the Pan American entities regarding the different branches of engineering by:

(1) fermenting the individual or collective visits among member countries and other interesting places, and

(2) the interchange of professors, lecturers, engineers and students among universities, schools and engineering associations."

As with many international organizations, a great deal of the time of the conventions is given to the establishment of rules and protocol. However, this fourth convention, for the first time, sponsored two round tables of general interest.

Round Table Discussions

The first round table was on the subject of atomic energy, under the chairmanship of Dr. Goodman of the Atomic Energy Commission. The purpose of this round table was to inform the delegates of the Pan American countries about the procedures necessary to establish a power industry in the various countries, based on atomic energy. The most important finding of this round table was that the first requisite for the establishment

of such an industry is properly educated individuals who would be in a position to design, build, and operate such facilities.

A second round table was on the subject of engineering education. Two sessions were held, the first on Wednesday evening, October 10. A prepared paper was presented by the writer on the "Needs of Cooperation in Engineering Education among the Pan American Countries." The second session, on Thursday morning, October 11, was a general discussion on ways and means of implementing cooperation among the Pan American countries in engineering education. Dr. Lee H. Johnson of ASEE was chairman of this session.

At the round table there were representatives of more than fifteen Pan American countries, with more than fifty persons in attendance in the morning session. As a result of the discussion, five areas of unanimous agreement were presented to the UPADI Board of Directors, as follows:

1. There is a great need in engineering education in the Latin American countries for the employment of full-time professors at salaries that would be attractive.

2. The well-being of engineering education is a joint responsibility of industry and government. Both agencies must bear their fair share of the load in all the Pan American countries.

3. There is need for study by engineering educators in all the Pan American countries of the basic requirements in engineering. This applies both to the curriculum and the facilities needed for the curriculum.

4. It is strongly recommended that the next convention of UPADI have a meeting of educators from various countries to discuss areas of mutual interest.

5. It is urged that a permanent committee of UPADI be formed for engineering education. This committee should operate in the interim between UPADI conventions.

The Board of Directors accepted these recommendations from the engineering education round table. It is probable that the permanent committee recommended will be set up and that the next convention of UPADI will have several sessions on engineering education.

UPADI will meet again at Montreal, Canada, in 1958. The exact time will be set by the Engineering Institute of Canada to coordinate with the World Power Conference scheduled for the same year.

ENGINEERING COLLEGE ADMINISTRATIVE COUNCIL

OFFICERS, 1956-57

Chairman: W. T. ALEXANDER, Northeastern University, Boston, Mass.

Secretary: R. A. MORGEN, Purdue Research Foundation, Lafayette, Ind.

Executive Committee: H. E. WESSMAN, University of Washington; J. R. CUDWORTH, University of Alabama; E. C. EASTON, Rutgers University; P. E. HEMKE, Rensselaer Polytechnic Institute, J. R. VAN PELT, Michigan College of Mining and Technology.

COMMITTEES

International Relations: H. W. Bibber, Union College, Chairman; P. G. Carter, Harold Flinsch, Mississippi State College; H. F. Marco, South Dakota State College; W. L. Orr, University of California at Los Angeles; Ernest Weber, Polytechnic Institute of Brooklyn; J. G. Young, University of Michigan

Military Affairs: J. H. Lampe, North Carolina State College, Chairman; H. W. Barlow, Washington State Institute of Technology; G. B. Carson, Ohio State University; P. E. Hemke, Rensselaer Polytechnic Institute; L. H. Johnson, Tulane University; R. H. Roy, Johns Hopkins University; J. F. D. Smith, Iowa State College; Harold Torgerson, New York University; H. E. Wessman, University of Washington

Secondary Schools: J. F. D. Smith, Iowa State College, Chairman; R. H. Carlton, A. H. Metcalf, Dartmouth College; S. H. Pierce, University of Illinois; R. C. Potter, Kansas State College; H. A. Romanowitz, University of Kentucky; M. O. Schmidt, University of Illinois; A. R. Spalding, Purdue University; E. B. Stavely, Pennsylvania State University; E. R. Wilcox, University of Washington

Selection and Guidance: R. H. Roy, Johns Hopkins University, Chairman; A. R. Hellwarth, Detroit Edison Company, Vice Chairman; D. S. Bridgman, American Telephone and Telegraph Company; N. L. Freeman, New York State Education Department; E. D. Howe, University of California at Berkeley; W. G. Ireson, Stanford University; R. F. McCoole, Monsanto Chemical Company; W. D. McIlvaine, University of Michigan; J. C. McKeon, Westinghouse Electric Company; N. A. Parker, University of Illinois; D. R. Saunders; S. P. Shackleton, Bell Telephone Laboratories; H. L. Solberg, Purdue University

Committee to Study Accreditation of Individual States (ad hoc): E. C. Easton, Rutgers University, Chairman; W. L. Everitt, University of Illinois; G. A. Marston, University of Massachusetts

THE VINCENT BENDIX AWARD

This award, consisting of a gold medal and a bronze replica, honors leaders in engineering education who have made outstanding contributions to the advancement of engineering research programs in colleges and universities. Sponsored by the Engineering College Research Council with the assistance of the Bendix Aviation Corporation, the Award is presented each year by the American Society for Engineering Education at its Annual Meeting in June. The Medal is named for Vincent Bendix, imaginative pioneer in developments for the automotive and aviation industries. This major award also symbolizes the role of research in engineering education: The development of new frontiers of knowledge; the better understanding of the forces of nature including their control and application for the benefit of mankind; and the enrichment of the total educational program.

Qualifications

Candidates for the Bendix Award should have demonstrated sustained contributions of a superior nature in one or more of the areas of engineering college research activities listed below. In many cases, the candidates will have excelled in several combinations of these areas, including:

(1) Formulation of fundamental theory and principles;

(2) Analysis and investigation of fundamental theory through productive research programs, conducted personally or by others under his direction;

(3) Conception of ideas and invention;

(4) Identification and support of worth-while efforts of others, including both active direction and general administration of research programs.

Selection Procedure

The Bendix Award Committee welcomes suggestions of suitable candidates, who may be nominated by colleagues, by research workers in industry or in other educational institutions, or by anyone familiar with the candidate and his contributions to engineering college research. There are several stages to the actual recommendation; first, the attached preliminary nomination form should be filled out and returned to the Chairman of the Bendix Award Committee, Professor Ross J. Martin, College of Engineering, University of Illinois, Urbana. Upon receipt of this proposal, detailed supporting data sheets, with instructions, will be sent to the sponsor. These data sheets must be returned to the Chairman prior to March 1, 1957.

With a view to limiting the work required of sponsors as well as assisting the Committee, brevity and simplicity are emphasized in completing the data sheets. Specific information required for the data sheets will include a brief citation of the candidate's accomplishments and the reasons why he should receive the award. Also required is a biographical sketch including a record of the nominee's discoveries and other direct contributions to engineering college research, technical publications, and other principal activities. As many as six letters of endorsement may be submitted if the sponsor considers such testimony to be helpful.

Information can be obtained from the Chairman or members of the Committee, and from the ASEE Secretary, W. Leighton Collins, Urbana, Ill.

THE CURTIS W. McGRAW RESEARCH AWARD

Purpose: the McGraw Research Award has been established to recognize outstanding early achievements by engineering college research workers under forty years of age, and to encourage the continuance of such productivity in the future. It is hoped also that such a prize will stimulate interest in engineering college research as an essential area of engineering education.

Sponsored by the Engineering College Research Council, with the assistance of the McGraw - Hill Book Company, the prize is named in honor of Curtis W. McGraw, whose efforts furthered the cause of research through the publication and dissemination of research results.

Nature of the Award: A cash prize of one thousand dollars and an accompanying engraved certificate will be presented each year at the Annual Meeting of the American Society for Engineering Education to a recipient selected by the Curtis W. McGraw Research Award Committee of the Engineering College Research Council.

Qualifications: (a) The candidate must have been active in one or more types of research ordinarily carried on by colleges of engineering or institutes of technology.

(b) While high quality of contributions is more important than quantity, the candidate should have achieved important advances which have been accepted by his colleagues and by other workers in the field of specialization. He should have a reputation for sound and productive thinking and should give promise of making further significant contributions.

(c) Typical evidence of outstanding research abilities would include not only discoveries and other original contributions to engineering fundamentals, but also the conception and improvement of laboratory techniques or devices, the publication of books, monographs, and scholarly papers, and activities in educational and professional societies.

(d) the candidate must not have reached his fortieth birthday by June 30 of the year in which the nomination recommends that he receive the award.

Nominations: The Committee earnestly requests that its knowledge of candidates be supplemented as much as possible by those related to engineering college research who admire some young co-worker. Candidates for the award may be sponsored by any person, group, or organization other than members of the Award Committee. The first step in the nomination procedure is to fill out the attached preliminary nomination form and send it to the Chairman of the Committee, Dean James R. Cudworth, University of Alabama, University, Alabama.

On receipt of this form, the Committee will return to the sponsors a set of data sheets on which the candidate's record should be reported. Specific information required for the data sheets will include a brief citation of the candidate's accomplishments. Also required is a biographical sketch including a record of the candidate's contributions to engineering college research, a list of technical publications, and information concerning other principal activities. In addition, the candidate may be supported by not more than six letters. Complete data must be returned by March 1, 1957.

ASEE CALENDAR OF EVENTS, 1956-1957

Meeting	*Date*	*Location*	*Chairman or Information*
Pacific Southwest Section	Dec. 27–28	University of Arizona	D. Whelan, Loyola U. of L. A.
Relations With Industry Division, College-Industry Conference	Jan. 30–31	University of California (Los Angeles)	C. Muhlenbruch, Educational and Technical Consultants
Cooperative Engineering Education Division	Jan. 10–11	Northeastern University	E. Hamlen, U. of Akron
Engineering Drawing Division	Jan. 30–Feb. 1	Rice Institute	I. L. Hill, Ill. Institute of Technology
Missouri-Arkansas Section	April 6	University of Arkansas	L. R. Heiple, U. of Arkansas
Southwest Section	April 18–19	Texas A. & M. College	E. M. Thomas, Texas Western
Allegheny Section	April 26–27	Penn State University	B. A. Whisler, Penn State U.
Ohio Section	April 26–27	University of Toledo	E. D. Harrison, U. of Toledo
Rocky Mt. Section	April 27	Brigham Young University	B. Brown, Brigham Young U.
Southeastern Section	April	University of Kentucky	M. Baker, U. of Kentucky
Michigan Section	May 4	General Motors Institute	C. L. Fanning, General Motors Institute
Pacific Northwest Section	May	Washington State College	M. C. Jenson, Washington State College
Illinois-Indiana	May 17	Northwestern	O. W. Eshbach, Northwestern U.
ASEE ANNUAL MEETING	JUNE 17–21 1957	CORNELL UNIVERSITY	J. C. Gebhard
Kansas-Nebraska Section	October	Kansas State College College	K. Razak, University of Wichita
North Midwest Section	October	Minneapolis, Minnesota	P. Cartwright, University of Minnesota

SECTION MEETINGS

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Pennsylvania State University	April 26–27, 1957	B. A. Whisler Pennsylvania State University
Illinois-Indiana	Northwestern University	May 17, 1957	O. W. Eshbach, Northwestern University
Kansas-Nebraska	Kansas State College	Oct., 1957	K. Razak, University of Wichita
Michigan	General Motors Institute	May 4, 1957	C. L. Fanning, General Motors Institute
Middle Atlantic	The Cooper Union, New York City	Dec. 1, 1956	G. B. Thom, Newark College of Engineering
Missouri-Arkansas	University of Arkansas	April 6, 1957	L. R. Heiple, University of Arkansas
National Capital Area	National Science Foundation	Oct. 2, 1956	W. J. Huff, University of Maryland
New England	Tufts University	Oct. 19–20, 1956	W. S. Evans, University of Maine
North Midwest	Minneapolis, Minn.	Oct., 1957	P. Cartwright, University of Minnesota
Ohio	University of Toledo	April 26–27, 1957	E. D. Harrison, University of Toledo
Pacific Northwest	Washington State College	May, 1957	M. C. Jenson, Washington State College
Pacific Southwest	University of Arizona	Dec. 27–28, 1956	D. Whelan, Loyola University of Los Angeles
Rocky Mountain	Brigham Young University	April 27, 1957	B. Brown, Brigham Young University
Southeastern	Brown Hotel, Louisville, Ky.	April 4–5, 1957	M. Baker, University of Kentucky
Southwest	Texas A. & M. College	April 18–19, 1957	E. M. Thomas, Texas Western College
Upper New York-Ontario	Union College	Oct. 13–14, 1956	W. H. Branch, General Electric Co. R. B. Russ, Union College

Members of the Society are welcome at all Section Meetings

Members have requested that the application blank be reproduced more often, so that it could be available for potential new members. Accordingly, it is printed below.

APPLICATION FOR MEMBERSHIP

Date .....

I desire to become a member of the American Society for Engineering Education and hereby agree to conform to the requirements of membership, if elected, and submit the following statement of qualifications:

Name .....
Print last name First Middle

Mailing address .....

City and State .....

Full title of
professional position .....
Title Department

Institution ..... Date of Birth .....

Degrees and names of institutions granting .....

Sponsors .....

.....

To be signed by two sponsors, members of ASEE, and returned to
W. L. Collins, Secretary, ASEE, University of Illinois,
Urbana, Ill.

American Society for Engineering Education

NOMINATION BLANK

ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before March 1, 1957 to the Secretary, W. Leighton Collins, University of Illinois, Urbana, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of General and Regional Activities — two years)

.....

For Treasurer .....

.....

Signed .....

Title.....

Institution .....

Date.....